SEAL OF THE STATE OF ILLINOIS
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STATE OF ILLINOIS

STATE GEOLOGICAL SURVEY

FRANK W. DE WOLF, Director

BULLETIN No. 20

YEAR-BOOK FOR 1910

ADMINISTRATIVE REPORT

AND

Various Economic and Geological Papers

Work in cooperation with U.S. Geological Survey

PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

ILLINOIS STATE GEOLOGICAL SURVEY
UNIVERSITY OF ILLINOIS
URBANA
1915

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BLOOMINGTON ILL

STATE GEOLOGICAL COMMISSION

LETTER OF TRANSMITTAL

STATE GEOLOGICAL SURVEY
UNIVERSITY OF ILLINOIS, December 1, 1915.

Governor E. F. Dunne, Chairman, and Members of the Geological Commission,

Gentlemen:—I submit herewith my administrative report for 1910, accompanied by miscellaneous papers of economic and scientific interest, and recommend that they be published as Bulletin No. 20.

The work covered in the report was actually accomplished during the administration of Governor C. S. Deneen, and advance publications were made several years ago to cover the more important features of the work. Thus, reports on the Carlyle oil field and the Carlinville oil field were given to the public in time to be of considerable assistance in developing the oil and gas resources. Similarly, statistics on mineral production for 1909 and 1910 were duly published in the press of the State. A report on the geological and mineral resources of the Springfield quadrangle, in abbreviated form, was published by the U. S. Geological Survey.

On account of the congestion in the printing office the publication of the full bulletin has been deferred until the present time.

Very respectfully,

FRANK W. DEWOLF, *Director.*

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By F. W. DeWolf, Director

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ADMINISTRATIVE REPORT FROM JANUARY 1, 1910 TO JUNE 30, 1911

INTRODUCTION

GENERAL

The mineral production of Illinois for the calendar year 1910 totaled \$141,809,121. As usual, coal, petroleum, and clay-products were leaders, and these materials particularly received the attention of the Survey. In addition a large amount of work was done on strictly scientific problems.

ORGANIZATION AND PERSONNEL

The organization of the Survey included a general office, and three technical sections as before, Geologic, Topographic, and Drainage, besides the Mine Rescue Service which was maintained under cooperation at Urbana. The geologic section was administered by F. W. DeWolf, acting director, who was appointed director in 1911. The topographic section was in general charge of R. B. Marshall, chief geographer, and in immediate charge of W. H. Herron, geographer of the central division for the U. S. Geological Survey. The drainage section was conducted by Mr. Herron and the director. The Mine Rescue Station has been in charge of R. Y. Williams, assisted by J. M. Webb, under the general supervision of G. S. Rice and J. W. Paul, all of the U. S. Bureau of Mines.

G. E. Carothers acted in the capacity of chief clerk, assisted by Miss Gertrude O'Brien, as stenographer and clerk.

Professors Salisbury, Grant, and Barrows continued to serve as consulting geologists, and Professors Parr and Bartow as consulting chemists. A. V. Bleininger, consulting ceramist, with R. T. Stull, ceramist, continued in general charge of the clay studies.

Professors Weller, Savage, and J. A. Udden, have given part-time service to the Survey as geologists. G. H. Cox, assistant geologist, continued the study of lead and zinc in northwestern Illinois and submitted his report early in 1910. E. W. Shaw of the U. S. Geological Survey mapped the Galena and Tallula quadrangles and the surficial deposits of the Galatia quadrangle in cooperation with the State Geological Survey. R. S. Blatchley, assistant geologist, with W. E. Deuchler, field assistant and draftsman, made studies in the southeastern oil field and enlarged our general oil report. G. H. Cady was employed temporarily as assistant geologist. He prepared the West Frankfort quadrangle report and nearly completed the field work on the La Salle quadrangle under Professor Grant. A. C. Trowbridge, assistant geologist, surveyed the Elizabeth quadrangle in cooperation with the U. S. Geological Survey. Carl O. Sauer, field assistant, prepared an educational bulletin on the Upper Illinois Valley under the direction of Prof. R. D. Salisbury.

Coal analysis and various chemical studies were carried on by J. M. Lindgren and D. F. McFarland, chemists, under the general direction of Professor Parr, of the University of Illinois. T. R. Ernest, field assistant, in collaboration with Professor Parr, carried on experiments in sand-lime brick and prepared their results for early publication.

A number of other men served for short periods of time in the field and office. The organization of the Survey was as follows:

COMMISSIONERS

Governor C. S. Deneen, Chairman
Professor T. C. Chamberlin, Vice-Chairman
President E. J. James, Secretary

ADMINISTRATIVE WORK

F. W. DeWolf, Director
G. E. Carothers, Chief Clerk

GEOLOGICAL SECTION

F. W. DeWolf, Geologist
R. D. Salisbury, Consulting Geologist
U. S. Grant, Consulting Geologist
Harlan H. Barrows, Consulting Geologist
S. W. Parr, Consulting Chemist
Edward Bartow, Consulting Chemist
A. V. Bleininger, Consulting Ceramist
Stuart Weller, Geologist
T. E. Savage, Geologist
J. A. Udden, Geologist
G. H. Cox, Assistant Geologist
E. W. Shaw, Assistant Geologist
R. S. Blatchley, Assistant Geologist
G. H. Cady, Assistant Geologist
A. C. Trowbridge, Assistant Geologist
R. T. Stull, Ceramist
J. M. Lindgren, Chemist
D. F. McFarland, Chemist
A. J. Ellis, Assistant Geologist

W. E. Deuchler, Field Assistant and Draftsman
T. R. Ernest, Field Assistant
Carl O. Sauer, Field Assistant
David G. Thompson, Field Assistant
Gertrude O'Brien, Clerk

TOPOGRAPHIC AND DRAINAGE SECTIONS

(Employes of the U. S. Geological Survey under cooperative agreement)
R. B. Marshall, Chief Geographer
W. H. Herron, Geographer of Central Division, including Illinois

Topographic Mapping:
Frank Tweedy, Topographer
F. W. Hughes, Asst. Topographer
B. A. Jenkins, do
L. L. Lee, do
O. H. Nelson, do
E. L. Hain, do
C. C. Gardner, do
H. W. Peabody, do
W. S. S. Johnson, do
J. B. Leavitt, Junior Topographer
W. S. Gehres, Topographic Aid

Primary Traverse:
J. R. Ellis, Topographer
C. B. Kendall, Asst. Topographer

Levels:
Carl R. French, Junior Topographer
J. H. Wilson, do
R. G. Clinite, Topographic Aid
S. R. Archer, do

COOPERATION

As in previous years the State Geological Survey has worked in close cooperation with a number of other organizations. With the U. S. Geological Survey there has been formal cooperation in the topographic work, in geological surveys of quadrangle areas, and in the collection of mineral statistics. Drainage surveys were continued in cooperation with the Internal Improvement Commission and the U. S. Geological Survey. Chemical studies on coal were carried on in cooperation with the Department of Applied Chemistry of the University of Illinois. The arrangement covering exchange of information with the State Water Survey has continued. Augustana College has furnished official facilities for J. A. Udden in his work of collecting and studying drill records, and the University of Chicago for the men writing educational bulletins.

Acknowledgment should be made to the numerous firms and individuals who have supplied the Survey with drill records and other notes, often of a confidential nature. The response to our requests for such information has been everywhere instant and hearty and the records now being collected and correlated will be of the highest value in the difficult task of working out the stratigraphy of the deeply buried portions of our great coal and oil fields.

GEOLOGICAL SECTION

The administration of the geological section of the Survey has been in charge of the Director. The principal work has been the continuation of stratigraphic and structural studies of the State based on drill records and the examination of outcropping rocks. The reports cover coal, oil, lead, and zinc, clay, water, and general educational topics.

GENERAL STRATIGRAPHY

As usual, an earnest effort was made to keep in touch with all of the drilling in the State and to collect the records for study. Mr. Blatchley spent three weeks in the field with an assistant, securing data for the enlargement of his general oil report published in Bulletin 16; and he and Dr. Udden arranged for complete samples of 35 deep wells. The results of Dr. Udden's examinations will appear as Bulletin 24, which promises to be an extremely valuable addition to our knowledge of the stratigraphy of the State.

Mr. Savage devoted two months to field work on the Devonian and pre-Devonian formations in the northern part of the State and in Calhoun, Jersey, and Alexander counties. He was assisted four weeks by Mr. Ellis. The results of this study will be published during the coming year. Mr. Weller spent two weeks in the field in Monroe County and devoted the remainder of his time to preparation of his monograph on the Mississippian brachiopods.

The coal-bearing rocks were examined in detail by Messrs. Savage, Shaw, Cady, DeWolf, Lines, and Udden, the first three devoting their time to detailed mapping of quadrangles in the southern coal fields.

No new work on clay or shale was undertaken but laboratory and burning tests on earlier samples were made by the Department of Ceramics, University of Illinois.

COAL

Much attention was given to the study of coal resources. The state produced 45,900,246 tons in the calender year 1910. During the fiscal year ended June 30, 1911, the output was 50,165,099[1] short tons as compared to 48,717,853 tons in 1910. The coal work has been in charge of the Director and has embraced not only the collection and study of a large number of drill records but also field examination in various parts of the State.

Reports on the Murphysboro and Herrin quadrangles by Messrs. Savage and Shaw were published in Bulletin 16 and manuscripts for folios on these areas will be submitted to the federal Survey for early publication. Mr. Cady's report on the West Frankfort quadrangle also appeared in Bulletin 16. Messrs. DeWolf, Lines, and Udden continued studies looking toward the preparation of a general coal report for the State.

Studies of coal resources of La Salle, Hennepin, Springfield and Tallula quadrangles were under way, and analyses were made of 15 samples from various mines. Other chemical investigations have been continued in cooperation with the Department of Applied Chemistry, University of Illinois, and Professor Parr has submitted a paper on the "Valuation of coal for gas manufacture" which appears in this volume.

The Mine Rescue Station, maintained in cooperation with the Department of Mining Engineering and the U. S. Bureau of Mines, has been actively engaged in training men for the new state stations. The men have responded to several calls for help in extinguishing mine fires. The work is in immediate charge of R. Y. Williams, assisted by J. M. Webb, both of the U. S. Bureau of Mines.

OIL AND GAS

The production of oil in Illinois in 1910 was 33,143,362 barrels as compared with 30,898,339 barrels in 1909. The increase in 1910 was largely due to deep drilling in Lawrence County, where the "Tracy" and "McClosky" sands were discovered. The Sandoval pool was opened up in 1909-1910 and the Carlyle field, which was predicted in the Survey reports, proved to be productive in the spring of 1911. A new gas area was tapped early in 1910 near Greenville, Bond County, where the wells yielded from 1,250,000 to 2,000,000 cubic feet of gas daily.

It was regarded advisable for Mr. Blatchley to report on the scattered developments throughout the state. Three weeks' field work with an assistant, in addition to previous collection of information enabled

[1]Coal Report of Illinois: Illinois Bureau of Labor Statistics, 1910.

him to complete the report appearing in Bulletin 16, issued January 1911. Besides information regarding developed fields, the report contains recommendations for future drilling in areas favorable for the accumulation of oil and gas. It is the intention to keep in close touch with operations and to make readily accessible any information that will be of value to the public.

LEAD AND ZINC

The Galena special topographic map including 20 square miles in the heart of the lead district was used as a basis for detailed geologic work by Mr. G. H. Cox. He is now completing a report on the lead and zinc deposits of northwestern Illinois, which will be published as Bulletin 21.

GROUND WATER

Dr. J. A. Udden continued his studies of stratigraphy based on deep well borings and made arrangements for complete samples from 35 such wells throughout the state. He studied these samples in great detail and obtained results which promise to be extremely valuable in the correlating of water-bearing beds.

CLAY

Detailed tests on the clay samples collected last season by Mr. Lines are being made by the Ceramics Department at the University of Illinois, and the results will probably be issued in a separate bulletin.

EDUCATIONAL BULLETINS

The preparation of educational bulletins under the direction of Prof. R. D. Salisbury of the University of Chicago, included field and office work on the Kaskaskia Valley, the Galena and Elizabeth quadrangles, and the Upper Illinois Valley.

MINERAL STATISTICS

The collection of mineral statistics, suspended in 1909 because the Census Bureau was engaged in a thorough investigation, was again undertaken in 1910 by the Survey in cooperation with the U. S. Geological Survey. The complete totals for 1909 and 1910 are given on a later page.

BUREAU OF INFORMATION

The Survey maintains a bureau of information for the convenience of inquirers about mineral resources of Illinois. Requests are received in great numbers both from inside and outside the state. When possible, a bulletin containing the desired information is mailed. Frequently, however, it is necessary to make special study and to reply by letter at some length. Many requests for the identification of minerals are received and answered promptly; others for analysis of specimens are, for the most part, necessarily refused. It has been found that the collection of a representative sample of a material, and the investigation of its favorable occurrence for development, is quite as essential and requires expert advice, just as does chemical analysis. As a rule, therefore, unless a representative of the Survey investigates and samples a mineral deposit, an analysis at public expense is not justified, particularly because otherwise Survey funds would be seriously depleted by work which frequently is of no permanent value. Preliminary examinations and opinions as to probable value of minerals, are always cheerfully given.

TOPOGRAPHIC AND DRAINAGE SECTIONS

In accordance with the cooperative agreement signed June 25, 1910, by George Otis Smith, Director, for the United States Geological Survey, and July 2, 1915, by Hon. Charles S. Deneen, Chairman State Geological Survey Commission, for the State of Illinois, the Federal and State surveys each allotted \$10,000 for regular cooperative topographic surveys in Illinois during the fiscal year ending June 30, 1911. In addition, the Federal Survey allotted \$1,250 and the State Survey \$3,750 for cooperative drainage surveys during the same period.

Table 1 presents a summary of field and office work accomplished from January 1, 1910, to June 30, 1911, under the general direction of Mr. R. B. Marshall, Chief Geographer, and under the immediate supervision of Mr. W. H. Herron, Geographer of the Central Division. The work from January 1 to June 30, 1910, was continued under the appropriations for the fiscal year ending June 30, 1910, the results accomplished during the first six months of that year being reported in State Geological Survey Bulletin No. 16.

TABLE 1.—*Progress of field work by the topographic and drainage sections*

Topographic surveys

Quadrangle	Counties	Publication scale	Area mapped	Levels		Traverse		
				Primary	Bench marks	Primary	Bench marks	Secondary
			Sq. mi.	*Miles.*		*Miles.*		*Miles.*
Milan	Rock Island, Mercer,	1:62,500	197	....	...	89	16	482
Waterloo,	St. Clair, Monroe,	1:62,500	234	67	17	....	..	948
Canton,	Fulton, Knox,	1:62,500	227	....	...	....	..	426
Kimmswick,	St. Clair, Monroe,	1:62,500	84	27	8	....	..	120
Colchester,	McDonough,	1:62,500	100	....	...	....	..	958
Renault,	Monroe, Randolph,	1:62,500	25	20	5	....	..	140
Rosehill and Eaton,	Cumberland and Jasper,		....	....	...	118	10	....
Canton, Avon and Glassford,	Fulton and Knox,		....	....	...	110	11	....
Macomb and Vermont,	McDonough, Fulton,		....	....	...	26	2	....
Carthage, Lomax, Keokuk, Colchester,	McDonough, Hancock, Schuyler,		....	24	10	133	15	....
Marseilles,	La Salle,		....	....	...	9	1	....
Ottawa,	La Salle,		....	....	...	25	2	....
Earlville,	La Salle,		....	....	...	9	1	....
Total			867	138	40	519	58	3074

Drainage surveys

Quadrangle	Counties	Publication scale	Area mapped	Levels Primary	Levels Bench marks	Traverse Primary	Traverse Bench marks	Traverse Secondary
Embarrass River,	Lawrence, Jasper, Crawford,	1:24,000	207	150	18	36	3	76
Spoon River,	Fulton,	1:24,000	37	47	5	31	3	..
Big Muddy River,	Williamson, Union, Jackson, Franklin,	1:24,000	...	61	...	...	...	...
Total........			244	258	23	67	6	76

The office drafting of the Waterloo, Canton, Milan, and Galena topographic maps was completed and the maps transmitted for engraving during the fiscal year. Progress in the drafting of incomplete maps was as follows: Kimmswick, 32 per cent; Embarrass River project 47 per cent; and the Spoon River project 80 per cent.

The adjustment of the levels for the Carthage, Colchester, LaHarpe, Lomax, Birds, Hardinville, Newton, Waterloo, Kimmswick, and Vincennes quadrangles was completed, the field notes typewritten and prepared for publication.

The final computation of the geodetic positions for the Carthage, Colchester, LaHarpe, Lomax, Augusta, Avon, Canton, Galesburg, Glasford, Good Hope, Havana, Macomb, Manilo, Maquon, Vermont; Milan and Madison (Ill.-Ia.), and Keokuk (Ill.-Mo.-Ia.) was completed and the results typewritten.

The data desired by the Internal Improvement Commission regarding profiles of the Big Muddy and Kaskaskia rivers were obtained, thus terminating our cooperation in that work. New surveys on Spoon River, completed from Seville to the Illinois, include 43 square miles. On Embarrass River, mapping was completed from Newton to the vicinity of Lawrenceville, an area of 94 square miles. In both cases reference marks were established for determining profiles when they shall be needed.

PUBLICATIONS

REPORTS

During the calendar year 1910 and the fiscal year ended June 30, 1911, the following reports were issued:

Bulletin 12, Physiography of the St. Louis Area, by N. M. Fenneman; Bulletin 13, The Mississippi Valley between Savannah and Davenport, by J. E. Carman; Bulletin 14, Year-Book for 1908; Bulletin 15, Geography of the Middle Illinois Valley, by H. H. Barrows; and Bulletin 16, Year-Book for 1909.

Other reports awaiting the attention of the printer, include:

Cement Resources of Illinois, Chemistry of Sand-Lime Brick, and Geography of the Wheaton Area.

The distribution of these reports so as to prevent waste, and yet make them most widely available, has been in itself a considerable task. It was thought that the interests of all concerned would be best met if 500 copies of each report were reserved for sale at the cost of printing, the receipts from the sales being turned into the state treasury. This makes it possible for libraries to complete their sets and for persons having real need for any of the volumes to obtain the earlier ones at small cost. The remainder of the edition is distributed by the survey and the Secretary of State to institutions and individuals making application for them, or is exchanged with other Surveys or publishing organizations.

Any of the published reports will be sent upon receipt of the amount noted. Money orders, drafts, and checks should be made payable to F. W. DeWolf, Director.

TOPOGRAPHIC MAPS

The accompanying illustration (Pl. I) shows the areas for which topographic maps have been prepared in cooperation with the U. S. Geological Survey. Those already published may be obtained from this office by remitting 10 cents for each copy. As the maps do not conform to county lines those desired should be ordered by quadrangle name.

The topographic maps are distributed also from Washington. They may be purchased at the rate of 10 cents each when fewer than 50 copies are purchased, but when they are ordered in lots of 50 or more copies, the price is 6 cents each. Drafts or money orders should be sent to the Director, U. S. Geological Survey, Washington, D. C. He is not allowed to receive postage stamps or personal checks in payment.

EXPENDITURES

The legislature in 1909 appropriated for the State Geological Commission for the new biennium as follows:

For the support and extension of the Survey.......$25,000 per annum
For making a survey of overflowed lands.......... 7,500
For preparing and engraving illustrations and maps, and for printing and binding................ 2,500 per annum

It has been the rule to allot $10,000 annually to topographic surveys from the general fund to meet an equal amount furnished by the U. S. Geological Survey.

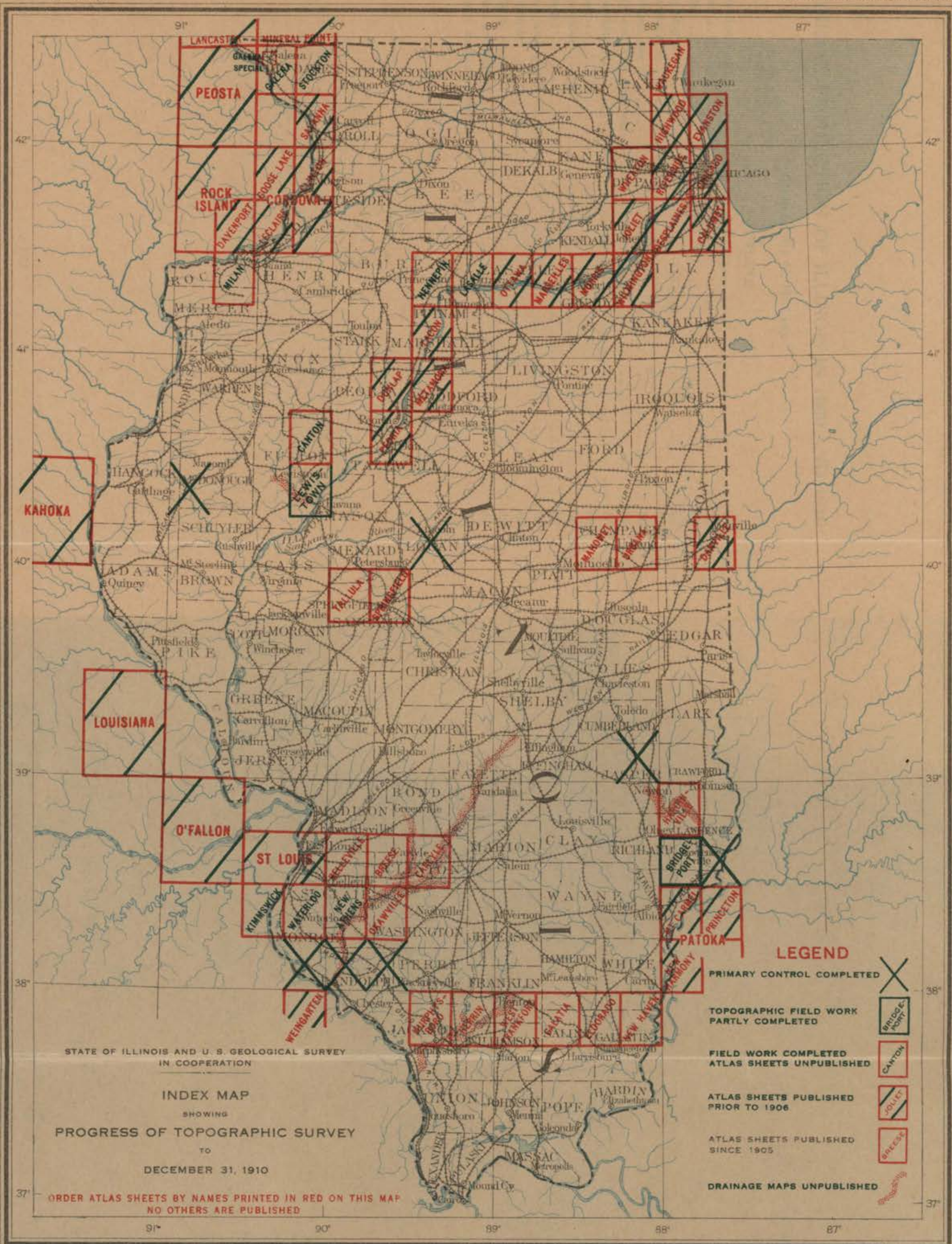
The total expenditures for the period from Jan. 1, 1910 to July 1, 1911 were as follows:

TABLE 2.—*Total expenditures Jan. 1, 1910 to June 30, 1911*

General Appropriation—		
Balance on hand Jan. 1, 1910	$ 6,225.51	
Appropriation July 1, 1910	25,000.00	
Total available	....	$31,225.51
Expenditures Jan. 1, 1910 to July 1, 1911—		
Salary and expenses of director and commission	$ 5,526.90	
Clerical help and general office expenses	4,178.69	
General stratigraphic studies	1,251.67	
Cooperative geology	1,785.23	
Surveys of oil fields	1,485.64	
Water resources	663.70	
Chemical work on coals	841.92	
Miscellaneous	445.64	
Statistics	54.87	
Studies of lead and zinc field	610.35	
Educational series	529.20	
Postage for distribution of bulletins	993.25	
Topographic surveys	10,992.53	29,359.59
Balance available July 1, 1911	....	$ 1,865.92
Special appropriation for survey and study of overflowed lands—		
Balance on hand Jan. 1, 1910	7,518.28	
Appropriation July 1, 1910	....	
Total available	....	$ 7,518.28
Expended Jan. 1, 1910 to July 1, 1911	....	6,831.99
Balance available July 1, 1911	....	$ 686.29
Preparation of illustrations and printing—		
Balance on hand Jan. 1, 1910	1,438.79	
Appropriation July 1, 1910	2,500.00	
Total available	....	$ 3,938.79
Expended Jan. 1, 1910 to July 1, 1911	....	3,410.68
Balance available July 1, 1911	....	$ 528.11

U. S. GEOLOGICAL SURVEY
GEORGE OTIS SMITH
DIRECTOR

ILLINOIS
STATE GEOLOGICAL SURVEY
FRANK W. DE WOLF, DIRECTOR



EXTRACT FROM U. S. G. S. BASE MAP

MINERAL PRODUCTION OF ILLINOIS IN 1909 AND 1910

Compiled By G. H. Cady

OUTLINE

MINERAL PRODUCTION OF ILLINOIS IN 1909 AND 1910

INTRODUCTION

The statistics for the mineral production of Illinois in 1909 were collected and compiled by the Census Bureau in cooperation with the U. S. Geological Survey; those for 1910 were gathered by the State Geological Survey in cooperation with the United States Geological Survey. The figures presented in the tables to follow are the final results of the tabulations of the United States Geological Survey for both years.

The industries included in the mailing lists are engaged in producing one or more of the following materials: coal, oil, gas, coke, clay, brick, tile, pottery, stoneware, sandstone, limestone, cement, sand, gravel, mineral waters, and mineral paints. The production is in most cases, to be published finally by county totals, except where there are less than three operators in one industry in the county. In this latter case the production of that county will be concealed by including it with that of some larger unit.

Table 3 shows total value of Illinois minerals since 1907; and also the value exclusive of pig iron which, in most part, is produced from minerals shipped into the State.

TABLE 3.—*Total value of Illinois mineral products 1907-1910*

	Value excluding pig iron	Value including pig iron
1907	$93,539,464	$145,768,464
1908	92,765,688	122,900,688
1909	98,840,729	143,051,729
1910	98,891,759	141,809,121

Pennsylvania with a mineral production valued at $554,044,102 and Ohio with a production valued at $193,214,492 led Illinois in total value of mineral products. Illinois, moreover, ranks ahead of Ohio if the value of pig iron is not considered.

In Table 4 are shown the quantity and value of the mineral products of Illinois in the calendar years 1908, 1909, and 1910.

TABLE 4.—*Output and value of mineral products of Illinois, 1908-1910*

Product	1908		1909		1910	
	Quantity	Value	Quantity	Value	Quantity	Value
Cement: Natural barrels	188,859	$68,772	....	(a)	....	(a)
Portland ....do.	3,211,168	2,707,044	4,241,392	$ 3,388,667	4,459,450	$4,119,012
Clay products	....	11,559,114	....	14,344,453	....	15,176,161
Coal ....short tons	47,659,690	49,978,247	50,904,990	53,522,014	45,900,246	52,405,897
Fluorspar........do...	31,727	172,838	41,852	232,251	47,302	277,764
Glass sand ......do...	194,722	139,172	224,381	153,226	268,654	216,531
Infusorial earth	....	(a)	....	39,262	....	33,390
Iron, pig.....long tons	1,691,944	30,135,000	2,467,156	44,211,000	2,675,646	42,917,362
Lead ....short tons	363	30,492	273	23,478	262	23,056
Lime ....do...	92,549	393,951	104,260	454,682	113,239	503,581
Mineral water.......... ....gallons sold	685,763	58,904	639,460	49,108	1,117,620	83,148
Natural gas	....	446,077	....	644,401	....	613,642
Petroleum ......barrels	33,685,106	22,648,881	30,898,339	19,788,864	33,143,362	19,669,383
Pyrite ......long tons	....	(a)	5,600	17,551	8,541	28,159
Sand and gravel...... ....short tons	6,463,026	1,363,850	8,930,848	1,796,271	....	(a)
Silver.fine ounces (troy)	2,000	1,100	900	500	2,000	1,100
Stone	....	3,134,770	....	4,261,818	....	3,853,425
Zinc ....short tons	298	28,012	675	72,900	351	167,508
Other products	....	a34,464	....	a51,283	....	a1,720,002
Total	....	122,900,688	....	143,051,729	....	141,809,121

a Includes in 1908: Infusorial earth, pyrite, sand-lime brick; in 1909: Natural cement, etc; in 1910: Natural cement, sand and gravel, sublimed blue and white lead, leaded zinc, zinc oxide.

COAL

The total production of coal in 1909 was 50,904,990 short tons, value $53,522,014. The total production in 1910 was 45,898,846 short tons, value $52,403,629.

As shown in Table 5 the value of coal production amounts to over 50 per cent of the total mineral output of the State. A table showing the output of coal in the State for the last five years is given below:

TABLE 5.—*Output and value of coal production in Illinois, 1906–1910*

	Short tons	Value
1906	41,480,104	$44,763,062
1907	51,317,146	54,687,382
1908	47,608,161	49,936,159
1909	50,904,990	53,522,014
1910	45,898,846	52,403,629

Mr. Edward W. Parker of the U. S. Geological Survey states[1] that Illinois contained in 1901 more coal-producting counties than any other state in the Union, there having been 52 counties that produced more than 1,000 tons each. In 1910 three of these counties, Hamilton, Jersey, and Kankakee, ceased producing.

Among the productive counties, Williamson was well in the lead in 1909 with an output of 6,537,654 tons. Sangamon County ranked second with 5,616,357 tons, Macoupin third with 4,597,775 tons. In 1910

[1]Parker, E. W., Coal production by states and territories: U. S. Geological Survey Mineral Resources, 1909, pt. 2, p. 114, 1911.

St. Clair County with an output of 5,788,567 tons took first place. Williamson County ranked second with 4,620,372 tons, and Sangamon County declined to third place with 4,449,634 tons.

The most significant new development is shown by the production of Saline County which increased from 2,552,137 tons in 1908 to 3,283,939 tons in 1909, a gain of 731,802 tons. Unnatural increases and decreases characterize the output of the various counties in 1910 due to the distribution of strike-affected areas. This accounts for the unusual production in St. Clair and Madison counties, and for the falling off in Williamson, Macoupin, Saline, and most of the other counties. Table 6 shows in order of production those counties producing over one million tons of coal in 1909 and 1910.

TABLE 6.—*Counties producing over one million tons of coal, 1909 and 1910*

Rank	1909		Rank	1910	
	County	Tons		County	Tons
1	Williamson	6,537,654	1	St. Clair	5,788,567
2	Sangamon	5,616,357	2	Williamson	4,620,372
3	Macoupin	4,597,775	3	Sangamon	4,449,634
4	St. Clair	3,471,630	4	Madison	4,102,773
5	Madison	3,373,798	5	Macoupin	3,854,229
6	Saline	3,283,939	6	Vermilion	2,515,250
7	Fulton	2,388,617	7	Saline	2,459,650
8	Franklin	2,316,509	8	Montgomery	1,799,720
9	Vermilion	1,919,955	9	Franklin	1,778,768
10	Montgomery	1,780,668	10	Fulton	1,721,527
11	La Salle	1,686,391	11	La Salle	1,178,885
12	Bureau	1,612,452	12	Perry	1,367,771
13	Perry	1,423,135	13	Christian	1,223,295
14	Christian	1,395,158	14	Randolph	1,025,557
15	Marion	1,171,950			
16	Grundy	1,114,101			

The average price per ton for coal at the mines during the last five years is shown below.

TABLE 7.—*Average price of Illinois coal at mines, 1906-1910*

1906	$1.08
1907	1.065
1908	1.048
1909	1.05
1910	1.14

Table 8 shows by counties the tonnage and value of Illinois coal produced in 1909 and 1910.

TABLE 8.—*Coal production of Illinois in 1909 and 1910 by counties, in short tons*

1909

County	Loaded at mines for shipment	Sold to local trade and used by employees	Used at mines for steam and heat	Made into coke	Total quantity	Total value	Average price per ton	Average number of days active	Average number of employees
Bureau	1,466,060	83,735	62,657	....	1,612,452	$2,667,714	$1.65	.....	......
Christian	1,240,629	91,922	62,607	....	1,395,158	1,361,080	.98	.....	......
Clinton	922,330	14,667	33,712	....	970,709	840,955	.87	.....	......
Franklin	2,232,716	22,898	60,895	....	2,316,509	2,344,708	1.01	.....	......
Fulton	2,242,852	91,199	54,566	....	2,388,617	2,687,916	1.12	.....	......
Gallatin	47,338	14,702	2,044	629	64,713	66,780	1.03	.....	......
Grundy	1,038,663	46,029	29,409	....	1,114,101	1,805,698	1.62	.....	......
Henry	62,510	69,342	5,208	....	137,060	213,299	1.56	.....	......
Jackson	576,350	41,150	34,780	....	652,280	787,867	1.21	.....	......
Knox	30	20,900	1,043	....	21,973	37,865	1.72	.....	......
La Salle	1,299,706	314,937	71,748	....	1,686,391	2,709,920	1.61	.....	......
Livingston	183,035	54,952	8,044	....	246,031	355,159	1.44	.....	......
Logan	315,505	49,661	30,722	....	395,888	420,949	1.06	.....	......
McDonough	1,640	14,636	....	....	16,276	32,599	2.00	.....	......
Macon	78,441	149,288	10,878	....	238,607	379,278	1.59	.....	......
Macoupin	4,435,247	55,796	106,732	....	4,597,775	4,262,484	.93	.....	......
Madison	3,208,365	81,999	83,434	....	3,373,798	3,018,927	.89	.....	......
Marion	1,088,738	36,863	46,349	....	1,171,950	1,040,326	.89	.....	......
Marshall	254,367	32,997	8,448	....	295,812	465,303	1.57	.....	......
Menard	262,739	33,596	7,613	....	303,948	331,420	1.09	.....	......
Mercer	326,740	29,985	13,037	....	369,762	494,778	1.34	.....	......
Montgomery	1,698,360	38,204	44,104	....	1,780,668	1,750,978	.98	.....	......
Peoria	768,096	123,837	23,028	....	914,961	1,080,478	1.18	.....	......
Perry	1,351,240	25,609	46,286	....	1,423,135	1,247,952	.87	.....	......
Randolph	762,873	22,797	14,223	....	799,893	732,147	.92	.....	......
Rock Island	13,535	30,525	2,168	....	46,228	67,792	1.47	.....	......
St. Clair	3,196,913	183,083	91,634	....	3,471,630	3,028,452	.87	.....	......
Saline	3,196,902	31,200	55,837	....	3,283,939	3,072,287	.94	.....	......
Sangamon	5,158,239	314,540	143,578	....	5,616,357	5,416,284	.96	.....	......
Scott	....	1,756	300	....	2,056	5,162	2.50	.....	......
Shelby	93,818	24,661	5,608	....	124,087	168,605	1.36	.....	......
Stark	6,016	16,334	809	....	23,159	38,715	1.67	.....	......
Tazewell	121,277	80,577	6,195	....	208,049	257,520	1.24	.....	......
Vermilion	1,628,841	236,132	54,982	....	1,919,955	1,899,735	.99	.....	......
Warren	....	11,440	864	....	12,304	25,683	2.09	.....	......
Will	146,294	11,918	4,095	....	162,307	254,530	1.57	.....	......
Williamson	6,271,779	73,062	192,813	....	6,537,654	6,354,491	.99	.....	......
Other counties[a] and small mines	897,101	262,018	49,679	....	1,208,798	1,796,178	1.49	.....	......
Total	46,595,285	2,838,947	1,470,129	629	50,904,990	53,522,014	1.05	.....	69,425

[a]Bond, Crawford, Greene, Hancock, Jefferson, Jersey, Kankakee, McLean, Morgan, Moultrie, Putnam, Schuyler, Washington, White and Woodford.

1910

County	Loaded at mines for shipment	Sold to local trade and used by employees	Used at mines for steam and heat	Made into coke	Total quantity	Total value	Average price per ton	Average number of days active	Average number of employees
Bureau....	867,063	63,626	42,657	......	973,346	$1,488,070	$1.53	157	3,294
Christian...	1,058,371	102,620	62,304	......	1,223,295	1,322,162	1.08	134	1,912
Clinton....	891,542	16,686	42,015	......	950,243	1,092,752	1.15	186	1,290
Franklin...	1,694,295	23,257	61,216	......	1,778,768	2,312,342	1.30	133	2,882
Fulton.....	1,611,261	66,469	43,797	......	1,721,527	2,253,307	1.31	145	3,448
Gallatin....	55,927	10,875	1,720	1,569	70,091	85,000	1.21	154	127
Grundy....	547,231	33,960	19,090	......	600,281	968,563	1.61	131	2,257
Henry.....	78,431	42,746	3,066	......	124,243	225,018	1.81	228	235
Jackson....	494,726	41,863	47,651	......	584,240	776,363	1.33	123	1,128
Knox......	....	27,549	746	......	28,295	54,174	1.91	200	81
La Salle....	839,173	290,656	49,056	......	1,178,885	2,032,002	1.72	171	3,171
Livingston..	105,208	49,625	8,065	......	162,898	262,056	1.61	135	413
Logan.....	337,604	50,230	21,410	......	409,244	469,657	1.15	152	788
McDonough.	9,252	16,843	243	......	26,338	61,194	2.32	181	88
Macon.....	116,471	110,306	8,584	......	235,361	387,713	1.65	177	492
Macoupin...	3,665,759	63,399	125,071	......	3,854,229	3,479,049	.90	176	4,570
Madison....	3,878,517	134,741	89,515	......	4,102,773	4,222,078	1.03	202	3,924
Marion.....	760,588	24,595	27,690	......	812,873	801,117	.99	152	1,256
Marshall...	213,590	44,545	9,312	......	267,447	466,724	1.75	159	1,032
Menard....	278,225	43,698	10,634	......	332,557	464,375	1.40	199	512
Mercer.....	201,081	19,025	8,918	......	229,024	343,115	1.50	138	560
Montgomery	1,709,995	50,284	39,441	......	1,799,720	1,907,006	1.06	159	2,374
Peoria......	683,440	113,232	13,923	......	810,595	1,042,478	1.29	157	1,463
Perry......	1,303,716	22,940	41,115	......	1,367,771	1,411,553	1.03	157	2,310
Randolph...	973,761	26,544	25,252	......	1,025,557	1,065,969	1.04	200	1,165
Rock Island	13,449	50,766	1,992	......	66,207	109,433	1.65	179	79
St. Clair...	5,417,001	241,940	129,626	......	5,788,567	5,763,249	1.00	195	5,598
Saline.....	2,389,033	30,811	39,806	......	2,459,650	2,713,514	1.10	134	4,248
Sangamon..	4,076,071	246,223	127,340	......	4,449,634	5,014,237	1.13	151	7,099
Shelby.....	105,504	24,893	5,275	......	135,672	179,291	1.32	137	354
Stark......	14,630	17,302	650	......	32,582	53,056	1.63	216	56
Tazewell...	90,800	62,166	2,693	......	155,659	210,824	1.35	174	327
Vermilion..	2,251,534	215,893	47,823	......	2,515,250	2,691,574	1.07	205	3,540
Williamson	4,354,824	57,281	195,286	12,981	4,620,372	5,086,928	1.10	133	8,050
Other counties[a] and small mines	730,657	229,025	47,370	......	1,007,052	1,589,954	1.54	150	2,522
Total....	41,818,730	2,666,614	1,400,352	14,550	45,900,246	52,405,897	1.14	160	72,645

[a]Bond, Calhoun, Greene, Hancock, Jefferson, McLean, Morgan, Moultrie, Putnam, Schuyler, Scott, Warren, Washington, White, Will, and Woodford.

COKE

Practically all coke made in Illinois is from mixtures of Illinois coal with Eastern coal in by-product ovens. Following are the statistics relative to the production in 1909 and 1910.

TABLE 9.— *Production of coke in Illinois, 1909 and 1910*

	1909	1910
No. of ovens used	468	508
Coke produced (short tons)	1,276,956	1,514,504
Value of coke produced	$5,361,510	$6,712,550
Value of coke per ton	$4.20	$4.43
Number operators		3

PIG IRON

In Table 10 the pig-iron production of Illinois is given for 1908, 1909, and 1910.

TABLE 10.—*Production of pig iron in Illinois, 1908-1910*

Blast furnaces								Production including spiegeleisen and ferro-manganese, in long tons		
In blast June 30,1909	Dec. 31,1909			In blast June 30, 1910	Dec. 31, 1910			1908	1909	1910
	In	Out	Total		In	Out	Total			
19	23	3	26	20	11	15	26	1,691,944	2,467,156	2,675,646

PETROLEUM[1]

PRODUCTION AND DEVELOPMENT

In reviewing the larger oil fields from the east westward the condition of declining production ceases when Illinois is reached. A total of 33,143,362 barrels produced in 1910 is almost the record output for the State and exceeds the total for 1909 by 2,244,023 barrels, or 7.27 per cent. In 1908 the product was 33,686,238 barrels. The increase in 1910 was due largely to the active drilling in the deep territory of Lawrence County, where two new sands, the "Tracy" and the "McClosky," were found beneath those previously known; but an equally interesting feature was the development of the Centralia-Sandoval pool in Marion County. Careful and thorough work of R. S. Blatchley enabled the Illinois State Geological Survey to indicate regions of probable petroleum pools and the actual and successful development followed in 1911, especially at Carlyle, in Clinton County. The credit for developing this Clinton County field belongs to the Illinois State Geological Survey, which, from structural considerations, pointed out this as a probable locality for an oil pool.

The following details of the developments in the Illinois field in 1910 are taken from a circular of the Illinois State Geological Survey by Raymond S. Blatchley, geologist:[2]

SOUTHEASTERN ILLINOIS FIELDS

Clark County.—The Clark County and adjoining shallow oil areas were almost inactive, and little drilling was done during the year. One profitable deep test was drilled to a depth of 2,969 feet by the Ohio Oil Co. on the K. and N. E. Young farm, near Casey. Oil and gas of considerable sulphur content were found at 2,750 feet, seemingly in the "Trenton" limestone. The combined daily output of the Clark, Cumberland, and Edgar County wells was about 9,000 barrels.

Crawford County.—Considerable drilling in Crawford County failed to prevent the decline of new production over 1909. The drilling was chiefly scattered over the entire pool during the greater part of the year. In the later months a concentration of development took place in the Bellair (Licking Township) area, where new produc-

[1]Day, D. T., Advance chapter from U. S. Geol. Survey Mineral Resources, 1910, pp. 61-66, 1911.

[2]The Illinois oil field in 1910.

tive sands between 1,000 and 1,100 feet were found. Many good wells were completed. The average well in the county is far below the previous initial yield, indicating the inevitable decline unless new sands are discovered. The yield reached about 30,000 barrels daily in 1910 as against 100,000 in 1907.

Lawrence County.—Highly profitable but expensive drilling took place in Lawrence County, where seven distinct sands produce oil in varying quantity and grade. They lie between 750 and 1,900 feet in depth, and in order are: The Bridgeport No. 1 and No. 2 sands, from 750 to 900 feet deep; the Buchanan sand, 1,275 to 1,400 feet; the Kirkwood sand, 1,550 to 1,650 feet; the Tracy sand, 1,700 to 1,750 feet; the McClosky sand, 1,825 to 1,860 feet, and the Green, Henry, and Pepple sands, from 1,850 to 1,900 feet deep, possessing a few wells each and very narrow limits. The McClosky and Tracy sands are the richest developed in Illinois. The former is in the ''King-Applegate pool.'' The chief activities of the year were in the two above-mentioned sands. Most of all the wells from these sands produced, initially, between 500 and 2,000 barrels. A short-lived impetus was given to the Lawrence County area early in the year, when a new pool was tapped on the outskirts of Lawrenceville, some 2 miles or more from the active fields. Two wells of 100-barrels yield were drilled, but several surrounding dry wells discredited the area. The average daily yield of the Lawrence County area was between 45,000 and 55,000 barrels. Both ''sour'' and ''sweet'' oils were produced, but each was handled separately.

Surrounding areas.—Considerable wildcatting was done several miles west and south of the present fields in Richland, Clay, Wayne, Gallatin, and Wabash counties, but without any showing of oil except in Gallatin County, where the amounts were small and insignificant. The area in Richland, Wayne, and Clay counties lies on or near the synclinal axis of the Illinois coal basin.

SOUTHERN CENTRAL AND WESTERN ILLINOIS

Marion County.—The best results from recent wildcatting were obtained in Marion County during 1909-10. The new Sandoval field of 4 wells in 1909, now, on December 1, 1910, has 35 producing wells yielding over 3,000 barrels daily, 16 dry holes, and 22 drilling wells. The oil comes from the Benoist sand, in the Chester formations of the Mississippian series of rocks, and is equivalent to the Kirkwood sand of Lawrence County. Its average depth is about 1,550 feet. A second pool was opened up during the year near Centralia, several miles south of the Sandoval area. Four light wells and several dry holes have been drilled. The productive sand is the same as that found near Sandoval. The two fields seem to lie along an irregular terrace upon the broad and gentle western flank of the Illinois basin. The general trend is to Duquoin, on the south, and to Brownstown and Pana, to the north. Much drilling is contemplated along this area.

Bond County.—A new gas area was tapped early in the year near Greenville. The sand was found between 950 and 1,000 feet and was correlated with the Benoist sand of Sandoval and the Kirkwood sand of Lawrence County. The wells yielded from 1,250,000 to 2,000,000 cubic feet of gas daily. A recent test was put down on the Brown farm, near Pocahontas, and secured an initial production of about 25 barrels at a depth of 1,975 feet. The pay seems to lie in the Niagara limestone. Much drilling is being done at the present time in an effort to develop both the gas and the lower oil pay.

WILDCAT WORK IN WESTERN ILLINOIS

Several light-pressure gas wells were drilled near Jacksonville, Morgan County, during the year. The yield came from a depth of about 300 feet and was odorless and colorless, but burned with a very hot blue flame. Several barren wells were drilled in Jefferson, Washington, Perry, Monroe, and Clinton counties. Much new drilling was started late in the year along the Sandoval-Duquoin terrace, especially in Washington and Perry counties.

On January 1, 1910, it was estimated that 16,497 wells had been drilled in Illinois. Of these, 2,379, or 14.4 per cent, were barren. In the first 11 months of 1910, 1,973 wells were drilled, with 430, or 21.8 per cent, barren. The total up to date is 18,470 drilled and 2,809, or 15.6 per cent, barren.

The total production, by months, for the last six years is given in Table 11.

TABLE 11.—*Production of petroleum in Illinois, 1905–1910, by months, in barrels*

Month	1905	1906	1907	1908	1909	1910
January	....	55,680	781,812	2,703,973	2,668,607	2,640,303
February	....	65,208	956,399	2,572,115	2,510,548	2,353,684
March	....	19,352	1,547,323	2,825,491	2,757,794	2,865,055
April	....	102,862	1,874,465	3,249,690	2,562,215	2,776,800
May	....	267,746	2,138,918	3,223,515	2,829,277	2,860,760
June	6,521	410,655	1,879,362	3,081,848	2,670,549	2,746,620
July	17,306	610,401	2,422,192	2,693,288	2,728,857	3,029,787
August	23,827	778,464	2,446,042	2,808,667	2,719,958	3,007,151
September	26,586	722,168	2,605,663	2,675,385	1,902,197	2,850,119
October	27,589	463,819	2,863,812	2,709,913	2,560,072	2,768,750
November	34,611	350,985	2,510,146	2,479,926	2,497,847	2,629,132
December	44,644	549,710	2,255,839	2,662,427	2,490,418	2,615,201
Total	181,084	4,397,050	24,281,973	33,686,238	30,898,339	33,143,362

TABLE 12.—*Production and value of petroleum in Illinois, 1905–1910, in barrels*

Year	Ohio oil Co.	Other lines	Total quantity	Total value
1905	156,503	24,581	181,084	$116,561
1906	4,385,471	11,579	4,397,050	3,274,818
1907	23,733,790	548,183	24,281,973	16,432,947
1908	31,972,634	1,713,604	33,686,238	22,649,561
1909	27,640,773	3,257,566	30,898,339	19,788,864
1910	27,751,090	5,392,272	33,143,362	19,669,383

TABLE 13.—*Production of petroleum in Illinois in 1909–1910, by kinds in barrels*

Year	Light	Heavy	Total
1909	28,049,468	2,848,871	30,898,339
1910	30,444,279	2,699,083	33,143,362

PIPE-LINE RUNS, DELIVERIES, AND STOCKS

The following tables show the runs of the Ohio Oil Co. during the years 1905-1910, and deliveries and stocks in 1907-1910, by months:

TABLE 14.—*Pipe-line runs, deliveries, and stocks of the Ohio Oil Co. in Illinois, 1905–1910, by months, in barrels*

Month	Pipe-line runs					
	1905	1906	1907	1908	1909	1910
January	....	55,680	752,671	2,497,359	2,494,492	2,220,842
February	....	65,208	918,620	2,464,914	2,358,198	1,976,637
March	....	19,352	1,494,598	2,591,911	2,568,392	2,377,012
April	....	102,862	1,823,025	3,089,417	2,388,309	2,306,336
May	....	267,746	2,094,195	3,084,816	2,536,413	2,374,134
June	5,489	410,655	1,830,634	2,965,786	2,365,956	2,274,501
July	9,208	610,401	2,376,281	2,579,977	2,413,218	2,569,830
August	15,092	778,464	2,398,895	2,690,931	2,411,483	2,528,532
September	19,592	722,168	2,560,593	2,555,871	1,595,934	2,409,232
October	26,444	463,819	2,818,032	2,582,561	2,228,269	2,334,659
November	34,766	350,985	2,464,981	2,356,386	2,149,372	2,211,286
December	45,912	538,131	2,201,265	2,512,705	2,130,737	2,168,089
Total	156,503	4,385,471	23,733,790	31,972,634	27,640,773	27,751,090

Month	Deliveries			
	1907	1908	1909	1910
January	142,001	1,720,631	324,887	1,226,379
February	401,344	1,882,978	869,212	842,135
March	444,078	1,010,459	721,519	882,209
April	385,432	1,476,192	891,423	936,706
May	563,585	1,869,461	903,838	946,346
June	551,502	1,846,947	1,077,383	1,156,895
July	1,395,238	2,012,288	1,176,410	1,332,242
August	1,440,640	1,774,354	1,052,431	1,229,479
September	1,105,589	1,488,283	849,533	1,135,323
October	1,590,566	1,394,983	938,860	1,245,778
November	1,815,964	1,284,304	1,120,751	997,805
December	848,450	1,789,158	685,585	1,036,260
Total	10,684,389	19,550,038	10,611,832	12,967,557

Month	Stocks			
	1907	1908	1909	1910[a]
January	2,509,598	14,129,954	25,876,529	28,355,182
February	3,040,111	15,069,278	26,203,238	28,356,243
March	4,117,635	15,975,633	26,630,509	28,373,855
April	5,528,759	17,420,534	26,856,675	28,593,365
May	7,117,033	19,077,020	27,593,494	29,025,647
June	8,448,344	20,456,387	27,899,220	29,106,098
July	9,387,999	21,036,143	27,627,086	29,198,965
August	10,355,000	22,267,197	27,683,334	29,177,382
September	12,557,522	23,485,690	28,399,427	28,879,676
October	13,724,691	24,396,787	28,535,636	28,492,136
November	14,275,036	24,905,168	28,373,985	28,086,619
December	15,751,305	25,252,468	28,671,543	27,348,358

[a] Includes some Indiana petroleum.

The following table shows the quantity of petroleum shipped by railroad from the Illinois oil field, 1907 to 1910, by months:

TABLE 15.—*Shipments of petroleum by railroad in tank cars from Illinois oil field, in pounds and equivalent in barrels, 1907–1910, by months*

Month	1907[a]		1908[b]		1909[c]		1910[d]	
	Pounds	Barrels	Pounds	Barrels	Pounds	Barrels	Pounds	Barrels
January	2,607,940	8,701	27,369,575	91,807	42,962,321	144,511	65,642,102	220,856
Feburary	4,361,996	14,598	21,191,859	71,170	33,135,044	111,407	64,727,081	217,917
March	7,158,170	23,947	39,352,395	132,300	45,220,034	152,056	78,297,914	263,056
April	12,609,699	42,249	35,198,236	118,074	32,756,603	109,872	76,629,857	257,292
May	47,076,459	158,227	25,177,339	84,290	46,914,958	157,783	84,174,328	283,285
June	49,701,853	166,644	36,566,990	122,317	54,585,149	183,432	84,794,030	285,095
July	96,137,954	322,622	32,087,310	107,688	47,158,942	158,642	82,242,109	276,533
August	66,661,072	223,134	20,912,433	70,171	49,602,064	166,943	82,505,800	277,317
September	21,203,105	70,555	24,771,903	83,042	51,574,673	173,509	75,462,070	253,788
October	17,055,726	56,570	30,427,564	102,163	59,425,540	200,067	63,301,200	213,217
November	16,831,726	56,080	41,096,712	138,147	58,881,214	198,044	85,453,500	287,750
December	19,952,993	66,692	37,751,352	126,967	55,130,392	185,166	69,768,400	234,819
Total	361,358,693	[e]1,210,019	371,903,668	[e]1,248,136	577,346,934	[e]1,941,432	912,998,391	[e]3,070,925

[a] Shipments were made from Duncansville, Lawrenceville, Stoy, Robinson, Bridgeport, Oilfield, and Casey. The railroads which shipped crude petroleum from Illinois were the Vandalia, the Baltimore & Ohio, the Cincinnati, Hamilton & Dayton, the Indianapolis Southern, and the Cleveland, Cincinnati, Chicago & St. Louis.

[b] Shipments were made from Duncansville, Lawrenceville, Stoy, Robinson, Bridgeport, Sparta, and Casey. The railroads which shipped crude petroleum from Illinois were the Vandalia, the Baltimore & Ohio, the Illinois Southern, the Indianapolis Southern, and the Cleveland, Cincinnati, Chicago & St. Louis.

[c] Shipments were made from Duncansville, Flat Rock, Lawrenceville, Stoy, Robinson, Bridgeport, Casey, and Sparta, the same railroads shipping in 1909 as in 1908, The number of tank cars shipped in 1909 was 11,820.

[d] Shipments were made from Duncansville, Flat Rock, Lawrenceville, Stoy, Sandoval, Bridgeport, Casey, and Sparta, the same railroads shipping in 1910 as in 1908 and 1909. The number of tank cars shipped in 1910 was 17,049.

[e] Calculations made according to specific gravity of the oil, ranging from 296.476 to 321.17 pounds to the barrel.

Prices

In the following table are given the dates of change and the changes in prices at wells of the different grades of petroleum produced in Illinois during the years 1908, 1909, and 1910:

Table 16.—*Fluctuation in prices, per barrel, of Illinois petroleum in 1908, 1909, and 1910*

1908			1909			1910		
Date	Above 30° B	Below 30° B	Date	Above 30° B	Below 30° B	Date	Above 30° B	Below 30° B
Jan. 1....	$0.68	$0.60	Jan. 1....	$0.68	$0.60	Jan. 1...	$0.60	$0.52
			June 26..	.65	.57			
			July 16..	.62	.54			
			Oct. 21...	.60	.52			

In the following table are given the average monthly prices paid for Illinois petroleum at wells in Illinois from 1905 to 1910, inclusive:

Table 17.—*Average monthly prices of Illinois petroleum, 1905–1910, per barrel*

Month	1905	1906	1907	1908		1909		1910	
				Above 30° B	Below 30° B	Above 30° B	Below 30° B	Above 30° B	Below 30° B
January........	......	$0.79	$0.64	$0.68	$0.60	$0.68	$0.60	$0.60	$0.52
February.......	......	.79	.65¼	.68	.60	.68	.60	.60	.52
March..........	......	.79	.67½	.68	.60	.68	.60	.60	.52
April..........	......	.80⅝	.68	.68	.60	.68	.60	.60	.52
May...........	......	.83	.68	.68	.60	.68	.60	.60	.52
June...........	$0.60	.83	.68	.68	.60	.67½	.59½	.60	.52
July...........	.60	.82¾	.68	.68	.60	.63⅜	.55⅜	.60	.52
August.........	.60	.71⅞	.68	.68	.60	.62	.54	.60	.52
September......	.61	.64	.68	.68	.60	.62	.54	.60	.52
October........	.64	.64	.68	.68	.60	.61¼	.53¼	.60	.52
November......	.66	.64	.68	.68	.60	.60	.52	.60	.52
December.......	.70	.64	.68	.68	.60	.60	.52	.60	.52
	.644	.745	.67⅜	.68	.60	.64⅝	.56⅝	.60	.52

Well Record

In the following tables is given the well record for Illinois from 1906 to 1910, inclusive:

TABLE 18.—*Number of wells completed in Illinois, 1906–1910, by counties*

County	Completed					Dry					Productive				
	1906	1907	1908	1909	1910	1906	1907	1908	1909	1910	1906	1907	1908	1909	1910
Bond....	....	....	....	....	7	....	....	....	....	6	....	....	....	....	1
Clark...	1,337	1,176	385	181	112	164	201	87	47	32	1,173	975	298	134	80
Coles....	65	56	9	12	5	14	11	1	3	1	51	45	8	9	4
Crawford	1,060	2,840	2,322	2,093	1,210	164	376	336	355	260	896	2,464	1,986	1,738	950
Cumberland...	558	152	42	33	17	53	13	11	10	4	505	139	31	23	13
Edgar...	37	25	9	6	2	16	14	2	4	2	21	11	7	2	....
Hancock.	....	....	....	....	1	....	....	....	....	....	....	....	....	....	1
Jackson.	....	....	....	3	2	....	....	....	2	2	....	....	....	1	....
Jasper...	....	....	....	18	8	....	....	....	11	4	....	....	....	7	4
Lawrence	176	691	762	724	689	33	70	78	56	95	143	621	684	668	594
Macoupin	....	....	....	9	2	....	....	....	8	2	....	....	....	1	....
Madison.	....	....	....	2	1	....	....	....	1	1	....	....	....	1	....
Marion..	....	....	....	23	60	....	....	....	17	26	....	....	....	6	34
Randolph	....	....	....	12	....	....	....	....	10	....	....	....	....	2	....
Saline...	....	....	....	2	1	....	....	....	1	1	....	....	....	1	....
Miscellaneous...	50	48	45	33	32	46	43	40	33	32	4	5	5	....	....
Total .	3,283	4,988	3,574	3,151	2,149	490	728	555	558	[a]468	2,793	4,260	3,019	2,593	1,681

[a] Includes 75 wells producing gas.

TABLE 19.—*Number of wells completed in Illinois, 1906–1910, by months*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1906...........	....	....	....	108	253	359	435	496	449	453	376	354	3,283
1907...........	253	356	351	387	493	639	521	461	400	363	430	334	4,988
1908...........	303	157	187	197	264	390	474	417	344	290	273	278	3,574
1909...........	213	224	216	263	321	342	346	303	282	242	223	176	3,151
1910...........	111	158	128	157	192	211	172	245	234	198	177	166	2,149

TABLE 20.—*Number of dry holes drilled in Illinois, 1906–1910, by months*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1906...........	....	....	....	20	37	41	69	82	69	47	64	61	490
1907...........	41	55	60	40	64	75	72	45	62	82	80	52	728
1908...........	55	22	37	33	35	54	65	55	49	51	47	52	555
1909...........	41	47	45	38	45	53	50	57	50	48	52	32	558
1910...........	17	43	29	41	43	50	43	47	48	30	39	38	[a] 468

[a]Includes 75 wells producing gas.

TABLE 21.—*Total and average initial daily production of new wells in Illinois, 1906–1910, by counties, in barrels*

County	Total initial production					Average initial production per well				
	1906	1907	1908	1909	1910	1906	1907	1908	1909	1910
Bond..............	......	......	......	......	25	....	....	....	....	25.0
Clark..............	31,060	20,385	6,953	3,219	1,802	26.5	20.9	23.3	24.0	22.5
Coles..............	279	314	122	95	65	5.5	7.0	15.3	10.6	16.3
Crawford...........	59,204	84,163	46,694	44,379	26,382	66.1	34.2	23.5	25.5	27.8
Cumberland.........	15,115	3,612	303	558	162	29.9	26.0	9.8	24.3	12.5
Edgar..............	101	118	45	10	......	4.8	10.7	6.4	5.0	......
Hancock............	......	......	......	......	5	....	....	....	....	5.0
Jackson............	......	......	......	3	......	....	....	....	3.0	......
Jasper.............	......	......	......	50	40	....	....	....	7.1	10.0
Lawrence...........	7,230	30,543	24,793	41,056	61,015	50.6	49.2	36.2	61.5	102.7
Macoupin...........	......	......	......	5	......	....	....	....	5.0	......
Madison............	......	......	......	10	......	....	....	....	10.0	......
Marion.............	......	......	......	223	3,760	....	....	....	37.2	110.6
Randolph...........	......	......	......	145	......	....	....	....	72.5	......
Saline.............	......	......	......	3	......	....	....	....	3.0	......
Miscellaneous.......	23	28	50	......	......	5.8	5.6	10.0	....	......
Total............	113,012	139,163	78,960	89,756	93,256	40.5	32.7	26.2	34.6	55.5

TABLE 22.—*Total initial daily production of new wells in Illinois, 1906–1910, by months, in barrels*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1906	....	....	.....	3,736	8,137	17,148	15,262	22,432	9,705	14,039	10,611	11,942	113,012
1907	9,433	9,842	10,392	11,083	13,329	18,807	17,375	11,240	10,967	8,157	9,780	8,758	139,163
1908	6,144	3,329	4,133	4,285	6,628	9,856	9,475	8,322	7,848	6,091	6,242	6,607	78,960
1909	5,060	4,833	5,018	5,237	7,681	9,050	9,820	8,661	8,324	8,904	9,628	7,540	89,756
1910	5,331	6,840	5,593	7,260	8,091	9,267	6,386	10,042	8,419	10,133	8,832	7,062	93,256

NATURAL GAS[1]

The condition of the natural-gas industry was practically the same in Illinois in 1910 as in 1909. The returns show a slight decline in output and value of gas produced. The total quantity of gas produced in 1910 amounted to 6,723,286,000 cubic feet, valued at $613,642, as against 8,472,860,000 cubic feet in 1909, valued at $644,401. The larger portion of this gas was utilized for industrial purposes, principally for the operation of engines and boilers in the fields.

With the exception of Bond County, no new developments were reported in 1910. In Bond County three gas wells have been drilled, the product of which is used to supply Greenville. Other cities and towns supplied in 1910 were Heyworth, supplied from shallow wells in McLean County; Carlinville, supplied from wells in Macoupin County; Vincennes, Ind., supplied from wells in Crawford County; Bridgeport, Casey, Olney, Lawrenceville, Sumner, New Hebron, Oblong, Palestine, Stoy, Duncansville, Flatrock, Birds, Pinkstaff, Hutsonville, Annapolis, Porterville, Robinson, Marshall, and Martinsville, supplied with gas from wells in Crawford, Clark, Cumberland, and Lawrence counties.

The number of productive gas wells in Illinois at the close of 1910 was 435, of which 64 were drilled in 1910. During the year 1910, 52 gas wells were abandoned.

TABLE 23.—*Record of natural-gas industry in Illinois, 1906–1910*

Year	Gas produced		Gas consumed			Wells		
	Number of producers	Value	Number of consumers		Value	Drilled		Productive Dec. 31
			Domestic	Industrial		Gas	Dry	
1906	66	$87,211	1,429	2	$87,211	....	....	200
1907	128	143,577	2,126	61	143,577	94	41	283
1908	185	446,077	[a]7,377	[a]204	[a]446,077	121	42	400
1909	194	644,401	[a]8,458	[a]518	[a]644,401	56	11	423
1910	207	613,642	[a]10,109	[a]479	[a]613,642	64	31	435

[a]Includes number of consumers and value of gas consumed in Vincennes, Ind.

[1]Hill, B., Extract from Mineral Resources of the U. S., 1910, pp. 316 and 317, 1911.

TABLE 24.—*Depth and gas pressure of wells in Illinois, 1908–1910, by counties*

County	Depth, in feet	Pressure, in pounds		
		1908	1909	1910
Bureau[a]	105– 330	0– 30	0– 23	0– 23
Champaign[a]	80– 130	....	....	15– 32
Clark	250– 550	65–100	38–100	35– 45
Crawford	500–1,550	25–400	45–275	20–225
Cumberland	500– 575	15– 35	40	....
De Witt[a]	94– 120	....	....	25– 50
Edgar	265– 600	....	....	75–127
Lawrence	1,400–1,652	500–600	200–580	200–750
Lee[a]	175– 280	....	....	18– 28
Pike	100– 893	3– 10	3– 7	4– 10

[a]From shallow, unconsolidated, glacial deposits.

CLAY AND CLAY PRODUCTS

The value of the clay and clay products of Illinois in 1909 was $14,-344,453 as against $11,559,114 in 1908. In 1910 the value was $15,176,-161. The increase from 1908 to 1909 amounted to nearly $3,000,000, and that from 1909 to 1910 to $831,708. The unusually high percentage of increase between 1908 and 1909 was due to the decrease in business in 1908. It seems probable that the coal strike in 1910 tended to decrease the amount of brick and other clay products manufactured in that year on account of the dependence of many of the plants upon local mines for their fuel.

Table 25 shows a summary of the value of clay products of Illinois for the five years from 1906 to 1910.

TABLE 25.—*Clay products of Illinois, 1906–1910*

Product	1906	1907	1908	1909	1910
Brick:					
Common—					
Quantity	1,195,210,000	1,494,807,000	1,119,224,000	1,257,025,000	1,196,526,000
Value	$5,719,906	$6,499,777	$4,834,652	$5,927,054	$6,896,836
Average per M..	$4.79	$4.35	$4.32	$4.72	$5.76
Vitrified—					
Quantity	122,227,000	126,927,000	138,362,000	140,105,000	115,903,000
Value	$1,306,476	$1,405,821	$1,622,496	$1,562,373	1,415,355
Average per M..	$10.69	$11.08	$11.73	$11.15	$12.21
Front—					
Quantity	30,022,000	20,828,000	22,851,000	32,416,000	22,138,000
Value	$341,298	$266,270	$301,515	$385,170	$274,699
Average per M..	$11.37	$12.78	$13.19	$11.88	$12.41
Fancy or ornamental ....value	$11,635	([a])	([a])	$12,223	$10,875
Enameled .....do	([a])	([a])	([a])	([a])	([a])
Fire ....do	$236,032	$241,008	$250,444	$682,793	$368,730
Stove lining .....do	([a])	([a])	([a])	....	....
Draintile ....do	$1,052,588	$1,031,192	$1,421,878	$1,613,593	$1,613,698
Sewer pipe ......do	$587,805	$662,487	$514,386	$394,461	$538,633
Architectural terra cotta ....do	([a])	([a])	([a])	$1,898,865	$1,680,438
Fireproofing .....do	$416,928	$429,535	$264,986	$439,796	$552,905
Tile, not drain...do	([a])	([a])	$124,425	$335,020	([a])
Pottery:					
Red earthenware ....do	$37,543	$37,045	$24,821	$31,771	$25,658
Stoneware and yellow and Rockingham ware..value	$897,650	$898,267	$733,373	$702,411	$708,958
White ware, including C. C. ware, white granite semi-porcelain ware, and semi-vitreous porcelain ware .....value	([a])	([a])	([a])	([a])	....
Sanitary ware..do	....	....	....	([a])	([a])
Porcelain electrical supplies ...value	([a])	([a])	....	....	....
Miscellaneous ...do	$2,026,320	$1,749,087	$1,466,138	$358,923	$1,089,376
Total value.......	$12,634,181	$13,220,489	$11,559,114	$14,344,453	$15,176,161
Number of operating firms reporting....	466	417	400	379	346
Rank of State......	5	4	4	4	4

[a]Included in "Miscellaneous."

Table 26 gives as far as possible the detail of the production of brick, tile, and pottery in 1909 and 1910.

The average price of common brick per thousand in Illinois in 1909 was $4.72; in 1910, $5.76: of vitrified brick in 1909, $11.15; in 1910, $12.21: of front brick in 1909, $11.88; in 1910, $12.41: of fire brick in 1909, $21.88; in 1910, $18.27. The great increase in the price of common brick was due to the increase in Cook County, where it rose from $4.20 in 1909 to $5.62 in 1910.

TABLE 26.—*Brick, tile and pottery production of Illinois, by counties*
1909

County	Common brick		Drain tile Value	Pottery Value
	Quantity Thousands	Value		
Adams	8,136	$57,208	$.......	$.......
Boone	....	....	5,000	....
Bureau	2,860	15,855	32,454	....
Cass	925	6,706	....	....
Champaign	6,980	43,526	....	....
Coles	....	....	17,500	....
Christian	2,775	18,360	26,025	....
Clark	900	5,700	....	....
Clinton	335	2,345	....	....
Cook	855,248	3,591,840	....	30,657
Edwards	1,117	7,768	....	....
Effingham	1,119	6,325	....	....
Fayette	2,961	20,450	9,700	....
Ford	....	....	10,352	....
Fulton	11,440	68,980	11,214	....
Gallatin	890	5,820	20,460	....
Greene	....	....	....	148,505
Hamilton	810	3,987	....	....
Henry	2,383	16,207	16,012	....
Iroquois	1,037	7,386	66,820	....
Jefferson	....	....	77,184	....
Kankakee	73,831	320,387	175,164	....
Lake	5,215	16,800	....	....
La Salle	9,457	101,521	185,522	21,786
Lawrence	....	....	32,559	....
Livingston	9,144	69,208	67,257	....
Logan	2,110	15,970	19,959	....
McDonough	1,830	12,765	28,109	258,290
McLean	6,650	39,675	45,533	....
Macon	9,523	70,323	....	....
Macoupin	1,593	10,240	....	....
Madison	15,682	91,892	....	....
Marion	2,875	17,438	....	....
Mason	1,000	6,000	....	....
Massac	500	3,413	....	....
Menard	2,833	17,812	7,169	....
Mercer	1,098	8,091	41,857	....
Montgomery	2,898	17,798	30,759	....
Morgan	600	4,380	35,330	....
Ogle	....	....	16,800	....
Peoria	7,750	47,900	....	....
Pike	702	4,350	2,350	....
Rock Island	11,575	69,383	....	....
St. Clair	40,899	262,756	....	....
Saline	2,640	16,740	....	....
Sangamon	15,050	97,402	20,396	....
Schuyler	1,600	8,900	....	....
Shelby	340	2,660	14,108	....
Tazewell	21,550	108,425	28,923	....
Vermilion	75,551	397,082	21,000	....
Wabash	750	4,575	....	....
Warren	1,425	10,225	74,144	....
Washington	1,748	10,663	....	....
White	1,490	9,680	29,975	....
Will	....	....	48,317	....
[a]Other counties	27,200	174,137	395,641	397,317
Total	1,257,025	5,927,054	1,613,593	838,555

[a]Including Alexander, Bond, Calhoun, Carroll, Crawford, De Kalb, DeWitt, Douglas, DuPage, Edgar, Franklin, Grundy, Hancock, Jackson, Jasper, Jefferson, Kane, Kendall, Knox, Monroe, Moultrie, Perry, Piatt, Pulaski, Randolph, Richland, Scott, Stephenson, Stark, Wayne, Williamson, and Woodford counties.

1910

County	Common brick Quantity Thousands	Common brick Value	Drain tile Value	Pottery Value
Adams	7,863	$59,270	$.......	$.......
Bureau	2,106	11,885	41,948	....
Cass	929	6,614	....	....
Christian	1,652	11,753	26,800	....
Clark	833	5,200	....	....
Coles	....	....	11,500	....
Cook	764,262	4,296,234	....	28,205
Edgar	....	....	2,500	....
Edwards	917	6,520	11,600	....
Effingham	435	2,280	140	....
Fayette	2,500	17,575	5,650	....
Ford	....	....	5,412	....
Fulton	14,034	88,919	....	....
Gallatin	1,100	7,200	10,500	....
Greene	....	....	....	124,639
Hancock	297	2,495	15,650	....
Henry	770	5,905	....	....
Iroquois	674	4,347	60,963	....
Kane	2,512	15,741	69,565	....
Kankakee	85,372	413,860	181,084	....
Knox	22,805	177,560	....	....
La Salle	2,130	15,062	217,335	....
Lee	....	....	35,300	....
Livingston	10,234	76,981	64,854	....
Logan	2,071	11,566	13,120	....
McDonough	2,710	19,950	31,021	....
McLean	5,708	35,956	37,268	....
Macon	8,640	53,880	....	....
Madison	18,217	100,554	....	....
Marion	1,390	8,250	2,250	....
Menard	3,213	19,516	9,242	....
Mercer	....	....	63,479	....
Montgomery	2,413	14,980	33,801	....
Morgan	490	3,545	26,000	....
Peoria	6,226	36,455	....	....
Rock Island	9,327	59,187	....	....
St. Clair	52,015	338,727	....	....
Sangamon	9,251	58,986	16,026	....
Schuyler	1,567	10,100	....	....
Shelby	335	2,376	11,740	....
Tazewell	15,903	88,015	....	....
Vermilion	....	....	14,776	....
Warren	1,125	8,200	106,638	....
Washington	2,990	16,917	....	....
White	2,120	14,200	33,076	....
Will	3,448	19,079	42,100	....
[b]Other counties	125,942	750,916	379,860	152,844
Total	1,196,526	6,896,836	1,603,698	844,747

[b]Including Alexander, Bond, Boone, Calhoun, Carroll, Champaign, Clinton, Crawford, DeKalb, De Witt, Douglas, DuPage, Edgar, Ford, Franklin, Greene, Grundy, Hamilton, Jackson, Jasper, Jefferson, Kendall, Lake, Lawrence, Macoupin, Mason, Massac, Mercer, Monroe, Moultrie, Ogle, Piatt, Pike, Pulaski, Randolph, Richland, Saline, Scott, Stark, Union, Wabash, Wayne, Williamson, and Woodford counties.

Table 27 shows the amount and value of clay mined in Illinois in 1909 and 1910.

TABLE 27.—*Clay mined and sold in Illinois in 1909 and 1910, in short tons*

	1909		1910	
Fire clay				
Quantity	45,806		82,878	
Value		$37,884		$111,078
Stoneware clay				
Quantity	33,098		42,410	
Value		27,886		34,202
Brick clay				
Quantity	26,255		13,704	
Value		19,943		16,344
Miscellaneous clay				
Quantity	38,901		49,811	
Value		29,155		29,272
Total				
Quantity	144,060		188,803	
Value		150,868		190,896

LIMESTONE

In 1909 the five leading counties in the production of limestone were as follows: (1) Cook, with a total production amounting in value to $2,504,377, over half the total value of limestone produced in the State; (2) Vermilion, the value in the table being concealed; (3) Will, value $383,759; (4) Kankakee, value $164,467; (5) St. Clair, value $133,049.

In 1910 the order of the five leading counties was: Cook, Union, Will, Kankakee, and St. Clair. The respective values of production, omitting Union, were $1,929,621; $421,063; $221,486; and $178,312. Vermilion County ceased producing.

LIME

Kilns where lime was burned during at least one of the two years (1909-1910) were located in the following counties: Adams, Carroll, Cook, Jo Daviess, Kankakee, Madison, Monroe, Rock Island, Whiteside, Will, and Winnebago. Cook County led with a value of production amounting to $278,000, or nearly two-thirds of the state total.

SANDSTONE

The counties producing sandstone in 1909 were Alexander, Carroll, Fulton, Henry, and St. Clair; St. Clair leading with a production valued at $26,891.

Table 28 shows the production of lime, limestone, and sandstone in 1908-1910.

TABLE 28.—*Value of lime, limestone, and sandstone, 1908–1910*

Year	Lime		Limestone	Sandstone
	Quantity	Value		
	Short tons			
1908	92,549	$393,951	$3,122,552	$12,218
1909	104,260	454,682	4,234,927	26,891
1910	113,239	503,581	3,847,715	5,710

CEMENT

The production of Portland cement in 1909 from the five mills of the State amounted to 4,241,392 barrels valued at $3,388,667, an increase of 1,030,224 barrels and $681,623 over the figures for 1908. In 1910 the production was 4,452,450 barrels valued at $4,119,012, an increase over the previous year of 211,058 barrels and $730,345. The average price per barrel of cement fluctuated from 84 cents in 1908 to 80 cents in 1909, and to 90 cents in 1910.

SAND AND GRAVEL

The statistics relative to the production of sand and gravel in Illinois in 1909 and 1910 are shown in Table 29.

TABLE 29.—*Production of sand and gravel in Illinois in 1909–1910*

	1909		1910	
	Quantity (short tons)	Value	Quantity (short tons)	Value
Glass sand	224,381	$153,226	268,654	$ 216,531
Molding sand	288,518	143,922	407,232	215,742
Building sand	1,917,915	632,273	1,756,652	473,209
Grinding and polishing sand	....	......	41,475	28,549
Fire sand	2,370	1,473	17,840	12,886
Engine sand	104,882	11,242	43,147	6,840
Furnace sand	22,840	13,700	79,793	48,046
Other sands[a]	3,188,885	277,056	1,170,089[a]	102,207
Gravel[b]	3,405,438	716,605	4,801,626	626,785
	8,586,508	1,730,795	9,155,229	1,949,497

[a]Chiefly sands used by railroads for filling.
[b]Gravel includes large quantity of sand used by railroads for filling.

Table 30 shows the value of the production of sand and gravel in Illinois by counties for 1909 and 1910.

TABLE 30.—*Production of sand and gravel*

1909

County	Producers	Glass sand		Molding sand		Building sand		Grinding and polishing sand		Fire sand
		Yards	Value	Yards	Value	Yards	Value	Yards	Value	Yards
Bond	3	......	......	26,935	$21,698	250	$ 100	......	......	.....
Bureau	6	......	......	2,855	1,613	28,837	7,434	......	......	.....
Carroll	4	......	......	......	......	1,670	1,250	......	......	.....
Cook	4	......	......	......	......	193,993	72,641	......	......	.....
Henderson	3	......	......	1,200	760	45,500	6,837	......	......	.....
Kane	19	......	......	23,031	10,070	296,417	96,365	......	......	.....
Lake	6	......	......	......	......	237,873	73,761	......	......	.....
La Salle	16	204,381	$139,226	201,437	81,324	21,975	19,695	......	......	520
Lee	8	......	......	600	600	21,643	11,213	......	......	.....
Logan	3	......	......	......	......	51,000	18,011	......	......	.....
McHenry	5	......	......	8,500	5,700	495,109	157,874	......	......	.....
Madison	3	......	......	11,014	12,108	1,450	750	......	......	350
Peoria	12	......	......	1,215	450	30,168	15,247	......	......	.....
Rock Island	3	......	......	......	......	58,112	11,925	......	......	.....
Vermilion	..	......	......	......	......	......	......	......	......	.....
Whiteside	5	......	......	3,384	2,817	5,940	3,650	......	......	.....
Will	8	......	......	400	240	59,571	23,483	......	......	.....
Winnebago	4	......	......	2,940	2,400	261,800	74,665	......	......	.....
[a]Other counties	..	20,000	14,000	5,007	4,142	106,607	37,372	......	......	1,500
Total		224,381	153,226	288,518	143,922	1,917,915	632,273	......	......	2,370

[a]Including: Alexander, Boone, DeKalb, Du Page, Fayette, Fulton, Hancock, Jo Daviess,

1910

County	Producers	Glass sand		Molding sand		Building sand		Grinding and polishing sand		Fire sand
		Yards	Value	Yards	Value	Yards	Value	Yards	Value	Yards
Bond	6	......	......	26,500	$21,575	5,065	$ 2,740	......	......	.....
Boone	4	......	......	......	......	1,903	850	......	......	.....
Bureau	5	......	......	6,260	3,556	31,473	9,247	......	......	.....
Carroll	4	......	......	......	......	1,284	536	......	......	.....
Kane	16	......	......	36,599	22,429	119,692	32,127	......	......	.....
Lake	3	......	......	......	......	17,457	3,500	......	......	.....
La Salle	19	231,276	$164,197	293,476	133,130	9,200	5,392	41,475	$28,549	7,590
Lee	5	......	......	41	37	3,603	1,925	......	......	.....
McHenry	5	......	......	12,000	6,200	585,000	160,000	......	......	.....
Madison	4	......	......	15,038	16,202	39,911	8,999	......	......	.....
Ogle	5	......	......	......	......	338	125	......	......	.....
Peoria	6	......	......	......	......	12,481	10,056	......	......	.....
Rock Island	3	......	......	......	......	110,313	27,845	......	......	.....
Tazewell	3	......	......	......	......	14,233	3,808	......	......	.....
Wabash	3	......	......	......	......	11,100	4,400	......	......	.....
Whiteside	4	......	......	4,323	3,555	1,987	1,060	......	......	.....
Will	7	......	......	720	432	89,189	28,576	......	......	.....
Winnebago	4	......	......	1,000	800	273,088	75,686	......	......	.....
[b]Other counties		37,378	52,334	11,275	7,826	429,335	96,337	......	......	10,250
Total		268,654	216,531	407,232	215,742	1,756,652	473,209	41,475	28,549	17,840

[b]Including: Cook, DeKalb, Fulton, Hancock, Henderson, Jo Daviess, Kendall, Logan,

in Illinois in 1909 and 1910, by counties

Fire sand	Engine sand		Furnace sand		Other sands		Gravel		Total	
Value	Yards	Value	Yards	Value	Yards	Value	Yards	Value	Yards	Value
.....	......	.....	....	......	125	$ 50	875	$ 420	28,185	$ 22,268
.....	......	.....	....	......	2,500	1,375	70,101	23,374	104,293	33,796
.....	......	.....	....	......	71,159	13,178	112,425	19,327	185,254	33,755
.....	......	.....	....	......	....	......	253,232	39,171	447,225	111,812
.....	66,141	$4,299	....	......	....	......	....	......	112,841	11,896
.....	......	.....	....	......	34,965	6,575	376,747	101,095	731,160	214,105
.....	22,500	3,750	....	......	....	......	70,893	21,381	331,266	98,892
$260	......	.....	22,840	$13,700	45,113	37,690	777,429	144,731	1,273,695	436,626
.....	300	200	....	......	....	......	18,617	9,620	41,160	21,633
.....	......	.....	....	......	....	......	21,340	7,343	72,340	25,354
.....	......	.....	....	......	2,784,583	183,528	228,155	65,106	3,516,347	412,208
438	......	.....	....	......	....	......	....	......	12,814	13,296
.....	1,080	550	....	......	1,620	600	272,823	54,302	306,906	71,149
.....	......	.....	....	......	....	......	19,975	5,963	78,087	17,888
.....	......	.....	....	......	1,620	1,200	18,000	3,600	19,620	4,800
.....	......	.....	....	......	150,000	10,000	503,578	60,130	662,902	76,597
.....	......	.....	....	......	1,950	1,500	330,685	74,169	392,606	99,392
.....	14,528	2,152	....	......	....	......	114,775	36,957	394,043	116,174
775	333	291	....	......	95,250	21,360	215,788	49,916	444,485	127,856
1473	104,882	11,242	22,840	13,700	3,188,885	277,056	3,405,438	716,605	9,155,229	1,949,497

Kendall, Mercer, Ogle, Randolph, St. Clair, Shelby, Stephenson, Tazewell, and Vermilion counties.

Fire sand	Engine sand		Furnace sand		Other sands		Gravel		Total	
Value	Yards	Value	Yards	Value	Yards	Value	Yards	Value	Yards	Value
....	......	.....	....	......	....	......	2,067	$ 1,180	33,632	$ 25,495
....	......	.....	....	......	1,300	$ 600	9,088	2,408	12,291	3,858
....	......	.....	....	......	....	......	75,935	30,460	113,668	43,263
....	......	.....	....	......	....	......	1,815	1,525	3,099	2,061
....	......	.....	....	......	4,994	1,331	517,720	67,509	679,005	123,396
....	19,650	$2,620	....	......	67,500	15,000	47,363	11,213	151,970	32,333
$4,036	602	361	79,793	$48,046	21,996	16,830	721,861	36,452	1,407,269	436,993
....	......	.....	....	......	1,500	1,250	1,608	314	6,752	3,526
....	......	.....	....	......	785,521	46,084	434,839	32,035	1,817,360	244,319
....	500	250	....	......	....	......	....	......	55,449	25,451
....	......	.....	....	......	....	......	297,769	32,521	298,107	67,980
....	......	.....	....	......	....	......	200,169	45,884	212,650	55,940
....	......	.....	....	......	....	......	20,458	7,826	130,771	35,671
....	......	.....	....	......	2,907	581	92.475	31,935	109,615	36,324
....	......	.....	....	......	....	......	30,913	9,900	42,013	14,300
....	......	.....	....	......	265,980	17,732	6.015	3,040	278,305	25,387
....	......	.....	....	......	1,300	900	398,662	43,458	489,871	73,366
....	17,280	3,200	....	......	17,091	1,899	1,125,000	134,500	1,433,459	216,085
8,850	5.115	409	....	......	....	......	817,869	134,625	1,311,222	300,381
12,886	43,147	6,840	79,793	48,046	1,170,089	102,207	4,801,626	626,785	8,586,508	1,730,795

Menard, Mercer, Piatt, Pulaski, St. Clair, Stephenson, and Vermilion counties.

FLUORSPAR

The production of fluorspar from 1908 to 1910 is shown by Table 31.

TABLE 31.—*Fluorspar marketed in 1908, 1909, and 1910, in short tons*

Year	Gravel		Lump		Ground		Total quantity	Total value
	Quantity	Value	Quantity	Value	Quantity	Value		
1908	21,332	$96,315	6,189	$33,267	4,206	$43,256	31,727	$172,838
1909	29,880	135,366	4,667	23,625	7,305	73,260	41,852	232,251
1910	35,477	178,880	6,151	38,415	5,674	60,469	47,302	277,764

MINERAL WATER

Table 32 shows the production of mineral water in Illinois in 1909 and 1910.

TABLE 32.—*Production of mineral water in Illinois in 1909 and 1910*[a]

Year	No. springs	Value	Total gallons	Medicinal water	Table water
1909	14	$49,108	639,460	$.....	$......
1910	16	83,148	1,117,620	2,485	80,663

[a]Exclusive of amount used for soft drinks.

SILICA OR TRIPOLI

The production of tripoli from Union and Alexander counties in southern Illinois in 1909 and 1910 was valued at $38,262 and $33,390 respectively.

SILVER, LEAD, AND ZINC

The total value of the productions of silver, lead, and zinc from the mines of Illinois in 1909 was $259,500 as compared with $417,208 in 1910. Table 33 shows the classified production.

TABLE 33.—*Mine production of silver, lead, and zinc in Illinois in 1909–1910*

Year	Silver		Lead		Zinc		Total value
	Quantity	Value	Quantity	Value	Quantity	Value	
	Fine ounces		*Short tons*		*Short tons*		
1909........	1,011	$ 526	295	$25,370	2,163	$233,604	$259,500
1910........	2,022	1,092	373	32,824	3,549	383,292	417,208

CARLYLE OIL FIELD AND SURROUNDING TERRITORY

By E. W. Shaw

U. S. GEOLOGICAL SURVEY

(IN COOPERATION WITH THE STATE GEOLOGICAL SURVEY)

OUTLINE

ILLUSTRATIONS

THE CARLYLE OIL FIELD AND SURROUNDING TERRITORY

INTRODUCTION

The excitement attending the discovery of oil at Carlyle in the spring of 1911 was unusually intense. In a very short time, however, systematic development began and the field took its place among the producers of the State. As development progressed, it became evident that the productive area had been outlined more or less clearly and general interest shifted to the question of the existence of other oil pools in the vicinity.

This report attempts to point out certain areas where the geological structure is favorable for the accumulation of oil and gas in the region surrounding Carlyle.

Area Treated in This Report

The present report is preliminary and somewhat general. It treats not only the developed oil field northwest of Carlyle, but a large part of Clinton, Washington, and St. Clair counties, and also parts of Monroe and Madison counties (see Plate II).

This district is on the whole a flat prairie, but there are numerous hills and valleys and considerable woods. The altitude ranges from less than 400 feet along some of the larger streams to about 600 at the tops of some of the hills in the central and northeastern parts, and 700 along the bluffs of Mississippi River. A large part of the surface lies between 460 and 480 feet above sea level. Kaskaskia River flows through the district from the northeast, receiving from the north the waters of Beaver, Shoal, Sugar, Silver, and Richland creeks, and from the south the waters in Crooked, Elkhorn, and Big Muddy creeks. The principal towns are Carlyle, Nashville, Okawville, Mascoutah, Trenton, Belleville, Freeburg, New Athens, and Marissa.

Acknowledgments

The basis of this report is a detailed survey of areas known as the Carlyle, Okawville, and New Athens quadrangles, made by the writer in the summer of 1911, together with observations in surrounding territory made in part by others in 1911 and preceding summers. The work was done under a cooperative agreement between the Illinois and the U. S.

Geological surveys. The material gathered by Professor J. A. Udden in the Belleville and Breese quadrangles, by Professor Stuart Weller in the Waterloo and Kimmswick quadrangles, and by R. S. Blatchley in the Sandoval oil field[1] has been freely drawn upon. Thanks is due to the many oil operators, contractors, drillers, and others who freely gave information, and particularly to those who kept careful logs and made other observations especially for the Survey. To all these the writer gratefully acknowledges his indebtedness.

Object and Methods of Work

The investigation which is the basis of this report was not primarily a study of the oil and gas of the region, but was intended to cover all lines of geologic work. It included the study of coal, clay, gravel, limestone, sandstone, and other rocks. The results were in part of immediate value in the exploitation of the mineral resources of the region, and in part purely scientific, having only an indirect economic bearing. Most of the observations were made on outcrops, surface features, and wells in the process of being drilled, but much information was obtained in the form of records of wells drilled both during and before the summer of 1911. In the producing oil territory the writer was able to visit most of the wells several times during the course of drilling and thus obtain first-hand knowledge of many of the strata being penetrated.

In this report the method of treatment will be first to describe the rocks of the entire region in general, and then those of the Carlyle oil field in particular, with the oil and gas that they contain.

Oil and Gas Prospecting

At first thought it would seem to be very difficult to work out the principles which govern the accumulation of oil and gas far below the surface. Indeed, after much careful observation many oil operators are only the more firmly convinced that no one before prospecting can tell anything about where these valuable resources exist. There is a common expression that "the drill only will tell the story." Many, if not most, men, when they begin to study the problem try to find something of significance in surface features. One, from his more or less limited experience, will say that valley bottoms are the best places to prospect; another, having had experience in a different district, will say that hilltops are best, and a third conceives that a certain peculiar arrangement of hills and valleys is most favorable. The geologist in Illinois can see no connection between surface features and oil and gas pools except in the obscure way that the "lay" of the rocks has affected the surface

[1]Blatchley, R. S., Illinois oil resources: Ill. State Geol. Survey Bull. 16, pp. 42-176, 1910.

relief. The bed rock in the Illinois oil fields is covered by a mantle of glacial drift, which commonly conceals the structure of the underlying strata.

GEOLOGY OF THE REGION

Stratigraphy

GENERAL DISCUSSION

Stratigraphy is a description of the layers of rock, including their order and relative positions. In Clinton, Washington, and St. Clair counties, and adjacent territory, all the known materials of the earth lying within three thousand or more feet from the surface are of sedimentary origin. They were once either in the form of particles or else dissolved in water, and they were all transported and deposited in their present position by water, or wind, or ice.

Most, if not all, of the limestones of the region were once limy muds such as are found on many parts of the ocean bottom today. In them were buried the shells of animals that lived in the sea at the time. The resulting layers of limestone with marine fossils show that in ages gone by southern Illinois lay beneath the sea.

The shales and clays were once ordinary muds—some of them deposited on the ocean bottom and some of them on land—for the region was not covered by sea water continuously. The marine mud consisted of fine sediment delivered to the sea by rivers from some land area and by waves which beat against the shore, just as sediment is being carried into the sea at the present time. In the sea water it slowly settled to the bottom and formed layers of more or less uniform thickness. The sea was then, as it is now, inhabited by animals and plants. Almost all of the plant and most of the animal matter decayed without leaving any impression on the bottom, but now and then conditions were such that hard parts, such as shells, when buried in the mud, left very definite impressions. We find these impressions or remains today and call them fossils.

Some of the shale and clay having no marine fossils may have been spread out on coastal plains a little above the level of the sea; some of it certainly was, for it contains impressions of land plants and animals.

The sandstone was once sand and was deposited in sea water, on land in lakes, or possibly by wind, for sand is carried and deposited in all of these ways; and since, as a rule, sand is poor material to receive and preserve impressions of plant and animal remains, and since other thoroughly reliable ways for distinguishing sea from land deposits have not yet been devised, it is not always possible to state what the origin of each of the sandstones has been.

Coal was formed in extensive marshes very near sea level. It consists of more or less disintegrated plant matter. Living plants are composed of water and many liquid and solid carbohydrates, resins, waxes, and other materials. Coal is made up of the same materials, except that most of the water and many of the products of the chemical transformation or decomposition of some of these materials have been pressed out.

The rocks of the earth form naturally several systems, each of which represents a long period of time—several millions of years. Not all of these systems are represented in the region under discussion (see Plates III and IV). The oldest definitely known to be present is the Ordovician, but this is no doubt underlain by Cambrian and still older rocks. The Silurian and Devonian, which lie above the Ordovician and elsewhere include strata thousands of feet in thickness, are thin in this area, and it is possible that the Silurian may be absent. Above the Devonian lies the Carboniferous system, which includes everything from the bottom of the Mississippian limestones to the uppermost hard rocks of the region. The age of the Carboniferous dates back about halfway in geologic time. Four systems above the Carboniferous are lacking and the only remaining one represented is the Quaternary to which belong the clay, sand, and gravel lying upon the shale, sandstone, and limestone of the Carboniferous system and forming the surface of all of this region.

The various layers of rock are described in order beginning at the bottom.

ROCKS OLDER THAN CARBONIFEROUS

In the region under discussion the Cambrian system lies so far beneath the surface that it has not been reached by the deepest wells. Judging by its character in other areas where it is known, it is probably a great sandstone about a thousand feet thick which is called the Potsdam. This rock is persistent and probably underlies all of southwestern Illinois.

The Ordovician system presumably comprises four principal divisions. The lowermost one does not outcrop and has not been reached in any of the deep wells. It is a magnesian limestone probably over 400 feet thick and has been called the Lower Magnesian limestone series or Prairie du Chien group.

The second division is the St. Peter sandstone. To the north where the rock is well exposed it is 100 feet or more in thickness and consists of well-rounded grains of sand.

Above the St. Peter is several hundred feet of rock which is predominantly dolomite, but includes some limestone and a little shale particularly in the lowermost part. This rock is frequently referred to as the Galena-Trenton limestone because it seems to be, in part at least, equivalent to the Trenton limestone of New York and other states, and in part to the Galena dolomite of northwestern Illinois, the relations of these formations not yet having been satisfactorily worked out. The exact thickness of these rocks in Clinton, Washington, and St. Clair counties is not known. Only the uppermost part is exposed and that is in the river bluff at Valmeyer in Monroe County. It is possible that over 400 feet are assignable to this division of the Ordovician.

The next beds are of Cincinnatian (Upper Ordovician) age and are more or less shaly. These, like the underlying beds, have not yet been identified with certainty because the well records are not detailed enough to give identification characteristics; but the rocks are probably present under the entire district, and if specimens containing fossils could be obtained, identification would be easy.

The Silurian system which includes the Niagaran group (the basal formation of which, in New York and other eastern states is the Clinton) is probably thin, if present at all, in the area under consideration.

The Devonian system for the most part is also difficult to identify from ordinary well records, but a hard black shale belonging in the uppermost part of the Devonian seems to be representative of the system. It is found in some of the deep borings, particularly those on the Petermeyer and Herzog farms near Carlyle, records of which are given below. Older Devonian strata probably underlie this shale and consist of limestone and sandstone as in Jackson and other counties.

The following records are of wells which have reached a part of the rocks described thus far (see also Plates III and IV).

Well No. 1, on Hergenroeder farm

Location—Sec. 20, T. 2 S., R. 9 W.

Altitude—560 feet.

Description of Strata	Thickness Feet	Depth Feet
Dark sand	50	50
Yellow lime	320	370
Dark shale	45	415
White lime	130	545
Gray lime	70	615
White lime	35	650
Red rock	10	660
Limestone	10	670
Flinty lime	40	710
Sandy lime	25	735
Red rock	60	795
White lime	170	865
White break shale	105	970

Well No. 1 on Hergenroeder farm—Concluded

Description of Strata	Thickness Feet	Depth Feet
Sand (oil)	2	972
Shale	8	980
Gray lime	15	995
Limestone, soft	100	1,095
Brown lime, hard	45	1,140
Gray lime	40	1,160
White flinty lime	20	1,200
Gray lime	20	1,220
Dark lime	40	1,260
Gray lime	60	1,320
Light gray lime	80	1,400
Gray lime	30	1,430
Gray lime	60	1,490
Water sand	15	1,505
Sand	107	1,612
Sandy lime	28	1,640
White sandy lime	10	1,650
Limestone	10	1,660
Break, "slate"	2	1,662
White lime	3	1,665
Gray sandy lime	3	1,668
Sandy lime	10	1,678
White sand	5	1,683
White lime	17	1,700
Oil sand (oil)	12	1,712
White lime	8	1,720
Water sand	5	1,725
White "slate"	5	1,730
White lime	40	1,770
Break, "slate"	5	1,775
Sandy lime	10	1,785
Brown lime	15	1,800
White lime	40	1,840
White sand (some water)	10	1,850
White lime	50	1,900
Break, "slate"	5	1,905
White sand	10	1,915
White lime (mostly)	85	2,000
Coarse white broken lime	10	2,010
Sandy lime	10	2,020
Water sand, hard	10	2,030
Broken sandy lime	40	2,070
White lime	30	2,100
Sandy lime	10	2,110
Dark brown lime	10	2,120
White salt sand	12	2,132
White lime	26	2,158
Light brown sand	7	2,165
Light brown sand	45	2,210
Light brown sand	38	2,248

Well No. 1, P. H. Postel Milling Company[1]

Location—At Mascoutah, sec. 32, T. 1 N., R. 6 W.
Altitude—420 feet (estimated).

Description of Strata	Thickness Feet	Depth Feet
Loess	30	30
Quicksand	5	35
Sand, white	5	40
Sand, gravel and other drift	64	104
Limestone	8	112
Shale, hard, coaly	30	142
Limestone	3	145
Coal (No. 6)	6	151
Shale	15	166
"Soapstone"	10	176
Shale	25	201
Coal	5	206
Shale, white	50	256
Shale, blue	40	296
Shale, white	45	341
Red rock	45	386
Shale	35	421
Shale "cave"	113	544
Limestone	5	549
Sandstone	45	584
Shale	25	609
Limestone	20	629
Red rock, probably a hard, calcareous shale	55	684
Shale, white	20	704
Sandstone (Benoist sand of drillers?)	20	724
Limestone	460	1,184
"Shale rock"	420	1,604
Limestone, shaly	390	1,994
Marl, red	70	2,064
Limestone	126	2,190
"Shale rock"	127	2,317
Limestone	449	2,766
"Shale rock"	58	2,824
Limestone	10	2,834
Shale and limestone	54	2,888
Sandstone and some shale	219	3,107

Well on Petermeyer farm

Location—7 miles northwest of Carlyle, sec. 17, T. 3 N., R. 3 W.
Altitude—469 feet.

Description of Strata	Thickness Feet	Depth Feet
Clay	20	20
Gravel, fine, well washed	38	58
"Limestone shells"	6	64
"Slate"	561	625
Sandstone	20	645
"Slate"	83	728
Sandstone	37	765
"Slate"	55	820
Sandstone	56	876

[1]It is reported that 2 barrels of oil per day have been gotten at times from this well.

Description of Strata	Thickness Feet	Depth Feet
"Slate"	14	890
"Slate", broken	80	970
"Limestone shells"	2	972
(Show of oil and gas and hole full of salt water at 975 feet).		
Sandstone	48	1,020
"Slate"	36	1,056
Sandstone	144	1,200
"Slate"	10	1,210
Limestone	565	1,775
"Slate"	10	1,785
Limestone	75	1,860
"Slate" and limestone	100	1,960
Limestone	220	2,180
"Slate"	90	2,270
Limestone	30	2,300
Shale ("pencil cave")	30	2,330
"Slate", black (Devonian?)	28	2,358
Limestone (salt water)	72	2,430

Well on Philip Herzog farm

Location—1 mile southwest of Carlyle, sec. 23, T. 2 N., R. 3 W.

Altitude—467 feet.

Description of Strata	Thickness Feet	Depth Feet
Clay and gravel	46½	46½
Shale and sandstone	393½	440
Limestone	5	445
Shale	5	450
Coal	7	457
Shale and sandstone	343	800
Sandstone (salt water)	50	850
"Slate"	185	1,035
Limestone	45	1,080
Red rock	18	1,098
Sandstone (salt water)	30	1,128
"Slate"	20	1,148
Sandstone (salt water)	91	1,239
"Slate"	14	1,253
Sandstone	122	1,375
Limestone	610	1,985
Shale	8	1,993
Limestone	212	2,205
Shale	155	2,360
Shale, black	30	2,390
Shale	145	2,535
Limestone, "Niagaran"	25	2,560
"Slate"	40	2,600
Limestone	133	2,733

It will be seen that the above logs do not show great detail. Some of the measurements are doubtless in error, but it is believed that the records are sufficiently accurate to give a good general idea of the succession of rocks, especially when Plates III and IV are studied.

Section of rocks exposed near Chester, Illinois

Description of Strata	Thickness Feet
Birdsville formation—	
Sandstone at Rockwood	100
Limestone	20
Shale, arenaceous, or shaly sandstone	33
Sandstone	10
Shale, arenaceous, or shaly sandstone	33
Limestone	54
Shale	42
Limestone (persistent)	8
Shale	36
(In some places a bed of sandstone occurs here with variable thickness up to 20 feet.)	
Limestone	4
Shale	4
Tribune limestone—	
Limestone (quarried at the Penitentiary)	80
Interval of uncertain character, lower part probably shale and upper part limestone	20
Limestone	49
Probably mostly shale	38
Shale, variegated red and green	15
Not exposed	5
Limestone, fossiliferous; Shale, fossiliferous	20
Limestone, very fossiliferous; Shale	15
Beds not observed	25
Cypress sandstone	134

The Chester is the uppermost group of the Mississippian beds in this region. Some drillers have fallen into the habit of speaking of that part of the Mississippian series which lies below the Cypress sandstone as the "Mississippi lime." This expression is undesirable, for the Mississippian series includes all of the Chester as well as the limestone formations below.

PENNSYLVANIAN SERIES

The Pennsylvanian series includes all the coal-bearing beds of Illinois, and is separated from the Mississippian by an uncomformity which marks a time when Illinois became dry land and remained so for a long period. In many drill holes the unconformity is not noticeable, and even where the rocks actually outcrop it is in some places not easy to locate. The uppermost Mississippian rock commonly still shows the effect of its exposure to the weather millions of years ago, being soft and brownish. The lowermost Pennsylvanian rock consists generally of a layer of cemented pebbles which is sometimes noted in well logs. It is difficult to distinguish from higher beds in which there are scattered pebbles.

Pottsville sandstone.—The Pottsville sandstone is composed of sandstone and shale and local thin lenses of coal. It is commonly known in the Carlyle oil field as the "salt sand." Near St. Louis the Pottsville is locally less than 20 feet thick and consists largely of clay. To the east it thickens to about 160 feet at Carlyle, south of which it is probably still thicker for it thickens generally in that direction and reaches over 500 feet in Jackson County. It contains no limestone, but is composed of several beds of sandstone separated by lenses of shale. Much of the sandstone is very porous, but some is almost as impervious as shale.

Carbondale formation.—The Carbondale formation extends from the top of the Pottsville sandstone to the top of the Herrin coal (No. 6),[1] which is the main coal bed of the region. Usually another bed of coal, the Murphysboro (No. 2) is present, forming the base of the formation, and still another about equally persistent lies almost exactly midway between the Murphysboro and Herrin coals, or about 125 feet below the latter. Still other coal beds are present in some places. Shale constitutes the major part of the formation, but there is much sandstone, particularly in the lower half, and a few layers of limestone, particularly in the uppermost and lowermost parts. Much of the shale is soft and clay-like.

McLeansboro formation.— The McLeansboro formation extends from the top of the Herrin coal (No. 6) to the highest hard rocks of the region, or somewhat above the limestone upon which drive pipe is commonly set in the Carlyle oil field. The Herrin coal is generally overlain by shale up to 30 feet thick, but locally this shale is absent and the overlying limestone rests directly on the coal. The limestone above the Herrin coal is even more persistent than the coal itself and may be used in an important way to determine the horizon of the coal where that bed is absent or questionable. The limestone contains a little fossil, scarcely as large as a grain of wheat, which can be identified even in the ground-up material from the drill hole. This limestone and the underlying coal are the most important key rocks in the region for they are persistent and easily recognized. Drillers should, therefore, make careful measurements to these beds so as to identify properly the sandstones of the Chester, some of which contain oil.

Above the limestone overlying the Herrin coal lies more than 300 feet of clay, shale, and sandstone generally free from limestone. This series of beds extends to the limestone which has been called Shoal Creek limestone in the Illinois State Survey reports, about 300 to 350 feet above the Herrin coal. The remaining beds of the McLeansboro formation are mostly soft shale and sandstone.

[1]The custom of using place names instead of numbers to designate the age of coal beds is generally desirable. It should be remembered, however, that the coals vary greatly in commercial importance from place to place and that the use of the same geologic name for coals of various districts implies only contemporaneous deposition—in no sense uniform quality. —Editor.

QUATERNARY SYSTEM

The Quaternary system includes the surface sand, clay, and gravel which, although it is many thousands of years old, does not average more than one-tenth as old as the rocks of the Carboniferous system. Much of this surface material is glacial. It was brought here by a great ice sheet that crept down from Canada bringing with it stones from that country very unlike the rocks of Illinois and leaving them spread over this region. Some of the rock and dirt was deposited directly by the ice and is a mass of clay (largely rock flour, ground by the glacier), sand, and gravel thoroughly mixed together. There are also beds of sand and gravel which were deposited on or in front of the ice. Upon this gravelly clay there is generally a bed of clay without any grit which was probably deposited by wind. This clay covers the prairie and the hills and valley sides, but the valley bottoms have a more recent deposit laid down by the streams.

SUMMARY OF GEOLOGIC HISTORY

The history recorded in the rocks shows that many millions of years ago southwestern Illinois lay below sea level. It was covered with salt water which was sometimes clear and sometimes more or less muddy. At times when it was free from ordinary mud it usually had some particles of lime which came from the breaking up of shells. At all times the solid material in the water was gradually settling to form layers of limestone, shale, or sandstone according to the kind of sediment. Such conditions prevailed throughout much of the Ordovician, Silurian, Devonian, and Carboniferous periods except that at several different times the surface rose above sea level and was land. This came about through very slow movements such as seem to have affected the outer part of the earth throughout its history and may be in progress today. There was no violent upheaval or eruption, for such events are recorded with great clearness and certainty in the rocks and could easily be detected. In the periods of emergence there were times when deposits of mud and sand accumulated on the land rapidly—just as today in favorable situations mud and sand accumulate on land as rapidly as under water. At other times deposition ceased and rain and streams washed away some of the material that had just been deposited. After such events, when deposition was resumed, the sediment was laid down on a more or less uneven surface and the result is now an *unconformity* in the rocks. The sea was not deep like the central parts of the great oceans but was shallow like the sea margins today within a hundred miles of land. The ocean migrated widely and occupied almost every possible position. Sometimes southwestern Illinois was possibly hundreds of miles from land and at other times it was just off shore. Sometimes land was nearer in one direction and sometimes in another. Probably there were times when the water that covered this region was an inland sea, being separated from the open ocean by a strip of land. Since Carboniferous time the region has in all probability been continuously a land area subject to the wearing and washing action of water and streams. If any sediment accumulated between Carboniferous and Quaternary time it was of small amount and has since been entirely removed. The Quaternary period was the time of glaciation. Within this period there were several epochs when ice advanced from the north, but only once did it reach southern Illinois. This time it buried the former surface under so much dirt and stones that after the ice had melted streams took new courses, in some cases at right angles to their old ones. Indeed the stream courses have not been the same in any two successive geologic periods, for in the first place all stream courses are slowly migrating, and in the second place every submergence means a more or less complete filling and obliteration of the valleys.

Structure

GENERAL STRUCTURE OF AREA

By structure is meant the arrangement and "lay" of the beds. The structure of this region as a whole is monoclinal; that is, the rocks dip in one general direction (to the east). Just east of St. Louis, the Herrin coal (No. 6) is about 400 feet above sea level, and it outcrops along the Mississippi bluffs. (See Plate II.) It slopes to the east, reaching sea level, or 450 feet below the surface, near Carlyle, and about 100 feet below sea level at Sandoval. The average dip is 10 feet to the mile. The rocks are highest in the southwestern part of the district where they were affected by an uplift which would carry the Herrin coal at Valmeyer in the western part of Monroe County up to more than 2,500 feet above sea level, or more than 1,800 feet above the present highest hill tops. In other words, at Valmeyer there are rocks outcropping at the surface which belong 2,000 feet below the Herrin coal (Pl. V).

The rocks do not have a uniform dip to the east but are folded into irregular shapes; moreover they are locally broken and displaced. In some places where there is a break, the rocks on one side have moved up several hundred feet above the rocks on the other side, and no one can tell how much lateral movement there has been.

The deformation just outside the region treated in this report no doubt affected the rocks in this area to a certain extent. At least the eastward dip described above is not regular, but the folds are very low and can be worked out only by careful measurements.

METHOD OF REPRESENTING STRUCTURE

The best method of showing the exact shape of any worked surface is by the use of contour lines, and the writer believes that it would be well worth while for every oil operator to become accustomed to the use of the contour map (see Plate II). The idea is simple—that of drawing lines through points of equal altitude on some particular rock surface—and the result shows the exact shape of that surface. For example, a contour map of the surface of the earth shows the form of hills and valleys; it shows not only where the slope is steep and where it is gentle; but also the degree of steepness and the altitude of every point.

The same idea is used in showing the structure of the rocks. A reference layer or surface is chosen—for example, the top of a certain coal bed. The altitude and dip of this surface are determined at as many points as possible and if these points are at all numerous, the altitude and dip in the unknown intervening areas can be determined with considerable accuracy by constructing a contour map. But in making a structure map the geologist is not limited to data on the one layer of rock upon which the map is based, for all the layers of rocks are approximately parallel and the distance between the beds can be determined. For example, in the Carlyle oil field there is a bed of limestone 340 to 350 feet above the Herrin coal and the position of the coal can be estimated with fair accuracy from the position of the limestone, without sinking a hole to the coal.

USE OF STRUCTURE CONTOURS

The structure map has numerous uses and none are more important than its use for oil and gas prospecting. A significant fact which many oil prospectors have failed to appreciate is that the oil pools of Illinois are without exception found where the rocks have a certain geologic structure. The oil is found in areas where the rocks are higher than in adjacent territory in at least two directions and commonly in three or four directions. It would appear therefore to be almost a waste of money to sink prospects in synclines or places where the rocks are lower than in surrounding territory.

ACCURACY OF STRUCTURE CONTOURS

The accuracy of structure contours depends on three factors: first, the accuracy of the altitudes obtained directly; second, the difference between the actual and the assumed distance to the key rock; third, the number and distribution of points on the key rock whose altitudes have been determined.

(1) In the area under consideration, good surface maps have been published and there are numerous bench marks showing exact elevations above sea. From these, level lines were run to all points where a recognizable stratum could be located in natural outcrop or artificial excavation. In many wells the drillers have not determined the depth of the coal with exactness, but in such cases the uncertainty has been reduced by checking the reported position of the coal with the determined positions of other strata at or near the same place.

(2) With regard to the second factor mentioned above, the strata are not exactly parallel, or, in other words, the distance between any two layers is not the same at all points. The variation is not great, particularly in a small district, and where the distance between the layers of rock is only a few hundred feet. In a single township the distance between any two strata is not known to vary more than 15 or 20 feet, and in general this distance has been measured in at least one place in every township. The possible error arising in this way is therefore believed to be small; not more than 20 feet at most and that in only a few places.

(3) The third factor is most important for, although in some districts there are numerous and well-distributed points at which the altitudes of recognizable strata have been determined, in many parts of the area such information is scarce because outcrops are few or wanting and no wells, test holes, or coal shafts have been sunk to a bed that can be recognized. The region in which information is most abundant is, of course, the Carlyle oil field. Elsewhere the lay of the rocks is best known where coal mines are most abundant.

In some places surface features can be used to a certain extent in working out the structure. The most conspicuous example is the uplift of the rocks in the western part of the area, resulting in higher country near the Mississippi than at some distance away. There are other areas where hard layers of rock have had an influence on the surface, but the effect is generally obscure because of the thick mantle of gravel and clay which was deposited over this region by the ice.

Allowing for the possible errors noted above, it may be assumed that the contour lines are accurate within one-half a contour interval, or 25 feet, but that locally there may be a greater error.

The prominent structural features of the region under discussion (Pl. II) are several more or less isolated domes, some of which are longer in one direction than in another and hence are better described by the word anticline.[1]

CARLYLE ANTICLINE

The Carlyle anticline or elongated dome is a very low arch, the central line of which extends from the Baltimore & Ohio Railroad about midway between Carlyle and Beckemeyer a little east of north for three or four miles. The highest part is near the middle where the rocks are only a little higher than they are to the north. They are, however, higher than the same beds to the east, south, or west and this dip of the rocks in three directions away from the center of the dome seems to be the most important fact in the development of an oil pool.

As every oil pool in Illinois is located on an upward bend in the rocks it would seem well worth while in prospecting to search for such localities.

At Carlyle and Beckemeyer and for some distance south and southwest the Herrin coal (No. 6) is 15 or 20 feet above the sea; to the east and southeast it dips to 50 or 60 feet below sea level in the vicinity of Huey. Northwest from Carlyle the coal rises toward the center of the field where it is 50 to 60 feet above the sea. West from Carlyle the coal dips gently again almost to sea level, but northwest it does not sink so low, and it is not known to lie within 25 feet of sea level anywhere northwest of the pool. To the north and northeast, however, it descends to an altitude of 15 to 30 feet above sea in a distance of 2 or 3 miles.

It may seem remarkable, but it is a fact that the shape of the Carlyle oil pool does not correspond to the shape of the anticline as it is developed in the coal-bearing rock. The place where the coal is highest is well to the northwest of the center of the pool; but when the variable thickness of the strata is remembered, the surprising fact is that the outline of the dome in the coal-bearing rocks is so near the outline of the pool. Layers of sandstone in particular vary greatly in thickness, and it is surprising that when many such layers are piled one on top of another the uppermost is so nearly parallel to the lowest.

Another important fact is that the structure of the rocks has no direct effect on the surface configuration. The fold is so slight and the processes which modify the surface (stream erosion, glaciation, and

[1] An anticline, it should be remembered, is an upward bend or wrinkle in the rocks. The upbend to which the word is generally applied has a much greater length than breadth. An upward bend having nearly equal length and breadth is more concisely described by the term dome.

others) have been so active that it requires a keen eye to pick out any surface features that are even indirectly controlled by the lay of the rocks.

IRISHTOWN ANTICLINE OR STRUCTURAL TERRACE

In the central part of Irishtown Township, 5 to 7 miles north and 2 to 3 miles east of Carlyle, the coal lies 50 to 70 feet above sea. The details of the structure in this vicinity are not known for there are few outcrops and artificial excavations which show recognizable strata, but the coal is certainly higher than it is midway between this district and the Carlyle anticline, and it is considerably higher than the same bed a few miles to the east. Apparently there is a low anticline here which plunges and fades out to the east. Two wells drilled here in the fall of 1911 obtained no showing of oil. The highest known point in the coal in Irishtown Township is at the Ohio Oil Company's well on the Michel farm near the middle of sec. 17, but as the sands and the coal are not absolutely parallel the highest point in the sands may be a mile or two away from the middle of sec. 17.

BARTELSO DOME

There is fairly good evidence of a low dome one to two and a half miles north and a little east of Bartelso. Five wells have been sunk in the vicinity of Bartelso, and both the coal and the sands seem to be rising toward a point a short distance to the northeast of the town and indications of oil have been found. Four to seven miles north and northeast of Bartelso the strata are low and probably barren of oil; but between this place and the town there is possibility of a pool.

HIGHLAND DOME

At Highland the rocks are 25 to 50 feet higher than they are two or three miles to the east, south, or west, the coal in the northwest part of town being 230 feet above sea; but a test hole 1,089 feet deep was sunk not far from the center of the dome in 1889 and no showing of oil or gas was found. It, therefore, seems probable that this dome, like some others, contains no oil or gas. The record of the test is as follows:

Record of test hole at Highland

Description of Strata	Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
Drift	66	......	66	......
Limestone	4	......	70	......
Shale, black	3	......	73	......
Clay	7	......	80	......
Clay, shale	16	......	96	......
Shale, black	6	......	102	......
Limestone, brown	28	......	130	......
Shale	55	......	185	......
Sandstone (water)	73	......	258	......
Clay, shale, blue	10	......	268	......
Clay	10	......	278	......
Red rock	2	......	280	......
Limestone	22	......	302	......
Shale	5	......	307	......
Sandstone, dry	12	......	319	......
Shale	12	......	331	......
Sandstone, dry	6	......	337	......
Shale	20	......	357	......
Sandstone (water)	39	......	396	......
Shale	20	......	416	......
Sandstone (water)	40	......	456	......
Shale, black	6	......	462	......
Sandstone, dry	6	......	468	......
Shale, black	35	......	503	......
Coal	1	10	504	10
Clay	10	......	514	10
Sandstone, "shell'	5	......	519	10
Coal	1	2	521	......
Clay	4	6	525	6
Shale, black	54	6	580	......
Sandstone (water)	25	......	605	......
Shale, black	25	......	630	......
Shale	75	......	705	......
Limestone	4	......	709	......
Shale	30	......	739	......
Sandstone (water)	29	......	768	......
Shale	27	......	795	......
Limestone, brown	6	......	801	......
Shale	4	......	805	......
Limestone	8	......	813	......
Sandstone, red	2	......	815	......
Shale, red	4	......	819	......
Sandstone (water)	8	......	827	......
Shale	3	......	830	......
Sandstone, brown	20	......	850	......
Red rock	12	......	862	......
Shale	6	......	868	......
Sandstone, brown (water)	19	......	887	......
Shale, sandy green	15	......	902	......
Sandstone, green	18	......	920	......
Sandstone, white (water)	92	......	1,012	......
Limestone	77	......	1,089	......

HOFFMAN DOME OR ANTICLINE

At Hoffman, about 11 miles east of Bartelso, the strata are high, the coal according to a diamond drill record being 37 feet above sea; whereas a very few miles to the northwest, north, and east, it is below sea level. It may dip to the south also, and if so the structural feature is a dome; otherwise it is an anticline, which plunges to the northeast. In either case it is well worth a test for oil.

The structure between Hoffman and Bartelso is not known. Most likely there is a shallow syncline, but there is a possibility of a small arch.

NASHVILLE ANTICLINE

At Nashville the strata have a noticeable rise to the west, but a mile north of Addieville they seem to be 50 feet lower. From what is known of the lay of the rocks there appears to be a broad, but fairly steep-sided, anticline plunging slightly to the northeast but perhaps extending without a break northeast to the Hoffman dome. There is some indication that the anticline is double crested, one crest being southeast and one northwest of Nashville. To the southwest the anticline becomes less pronounced. At Oakdale it appears to be broad and low, though farther to the southwest toward the Sparta field it may become higher and steeper. It may be, however, that this uplift is not an anticline but a dome. If so its position is 2 to 4 miles west of Nashville.

VENEDY DOME

In a deep well near the old town of Venedy about 6 miles southwest of Okawville the coal is reported to lie at a depth of 212 feet, or 250 feet above sea. This is higher than it lies in surrounding territory but the details of this dome or anticline are not yet known.

DARMSTADT ANTICLINE

The Darmstadt anticline has a northeast-southwest trend, and is somewhat irregular. It probably extends northeast to the Venedy uplift, beyond which it appears to be double crested, one crest running nearly north to New Memphis, and the other northeast to Okawville. The anticline seems to be highest near Darmstadt, where the coal bed reaches an elevation of 298 feet above sea, whereas it is 50 to 75 feet lower to the west, north, and east. It may or may not be lower to the northeast, and there is a possibility that it is lower to the south and is a dome. It is at least a well-marked uplift, flanked on the northwest and southeast by synclines, and is one of the most worthy places in the region for a test well.

WHITE OAK ANTICLINE

A low anticline plunging gently to the northeast extends in a southwest-northeast direction through White Oak, where it is unsymmetrical, the southeast limb being rather steep and about 40 feet high, and the northwest being less than 10 feet high. It thus has somewhat the form of a terrace facing southeast, but the distinct slope to the northwest makes it an anticline. To the southwest its limits are not known. It may extend as far as Baldwin. To the northeast it appears to broaden and to extend nearly to Lively Grove. The highest known point is 6 or 7 miles east and 2 miles north of Marissa, where the coal is reported in a test hole to be 295 feet above sea. This is higher than the coal lies either to the northwest, northeast, or southeast. But, unfortunately, there is very little information on the position of the strata in this district, and hence the structure is somewhat doubtful. There may be a dome just northwest of the middle of Lively Grove Township, and the anticline may be high or low, steep sided or gently sloping. But in any case, the anticline should be tested before adjacent territory. One test has already been sunk near White Oak, and no oil was found. Another test on this anticline might very well be located 5 or 6 miles northeast of White Oak.

OTHER ANTICLINAL FEATURES

At several places in the area under discussion, structures favorable for the accumulation of oil and gas have already been pointed out by R. S. Blatchley of the State Geological Survey (See Bulletin No. 16, Ill. Geol. Survey, 1911, pp. 42-177, inclusive). These places are enumerated by him as follows:

1. A flat "terrace" at O'Fallon.
2. A low arch at Aviston.
3. A small anticline west of Belleville, perhaps corresponding to the O'Fallon deformation.
4. A small arch east of the Belleville, perhaps corresponding to the O'Fallon deformation.
5. A small arch east of Mascoutah apparently corresponding to the Aviston deformation.
6. A probable structural terrace between Beaucoup and Ashley in Washington County.
7. A flat at Marissa.
8. An anticline at Tilden.

The new data on these features are indicated in the following paragraphs:

1. At O'Fallon the strata have the form of anticline rather than

a terrace, though the east limb is higher than the west limb. The anticline is somewhat broad at Aviston and to the north, in which direction it extends 3 or 4 miles. To the south it becomes narrower to a point just east of Belleville, beyond which it is not known to be developed.

2. At Aviston the general eastward dip of the strata seems to be modified by an upward bend, probably not over 15 feet in height. The arch falls between two of the 50-foot structure contours, and hence it is not shown on the structure map.

3. Concerning the small anticline west of Belleville no new data have been collected.

4. The anticline east of Belleville is, as indicated above, a continuation of the one at O'Fallon.

5. The presence of an arch east of Mascoutah was inferred from the fact that according to the log of the Postel No. 1 well, drilled in 1893, the coal lies higher there than in the Beatty mine half a mile north in the north edge of Mascoutah, but the fact that at the Kolb mine southeast of Mascoutah and in the Postel well No. 2 the coal is reported at about the same position as in the Beatty mine, and also the fact that in the coal mines the coal bed does not show any indication of anticlinal structure nearby, makes it appear probable that the Postel No. 1 record is slightly incorrect. In any case, since this well is not east of the Beatty mine, the anticline if present would be a small one in Mascoutah.

6. The record of the Shaffer and Smathers well near Ashley makes it appear that the structure between Beaucoup and Ashley is synclinal and not favorable for oil and gas accumulation, but not enough is known to warrant a definite statement.

7. The new information indicates that the beds at Marissa are bent downward forming a shallow syncline flanking the White Oak anticline on the northwest instead of being folded in a flat-topped anticline as previously thought.

8. The anticline at Tilden is much lower than was formerly supposed, being less than 10 feet in height. The crest lies about a mile west of Tilden.

CARLYLE OIL FIELD

History

The Carlyle oil pool was discovered early in April, 1911, two wells, Smith No. 1 and Murphy No. 1, reaching the pay sand within a few days of each other. Before this, two wildcat wells, about a thousand feet deep, had been drilled just south of Carlyle, and a showing of gas, hardly enough to stimulate prospecting, was found in one. The existence of producing wells 12 to 15 miles east of Carlyle in the Sandoval pool which was opened in the summer of 1909, served, however, to make men study the surrounding country, and in 1910 Murphy No. 1 was located by Mr. W. W. Laird, President of the Surpass Oil and Gas Company. It is about 5 miles northwest of Carlyle (see map of Carlyle oil field, Plate II). Plans were made to drill to a depth of 2,000 feet, and 13-inch casing was carried to 725 feet. Numerous difficulties were encountered and drilling proceeded slowly, so that it was several weeks before the hole reached a depth of 750 feet where a showing of oil was found. Late in the year another showing of oil was found at 860 feet. Further difficulties and accidents hindered the drilling and little progress was made through the winter. In March, 1911, the third sand containing oil was found at a depth of 1,013 feet and was shot with 60 quarts of nitro-glycerine. The shot failed to bring oil in paying quantities, but the drillers proceeded to clean out the well in the hope that it would turn out better, and a 250-barrel tank was built nearby. The oil found was enough to make holders of leases in the vicinity imagine that the well was just on the edge of a pool and a lease a short distance away might contain oil in paying quantities. The result was a test well half a mile south and a little east on the northeast corner of the Smith farm. The lease on this farm was held by F. B. Ranger and drilling was begun about the middle of March.

Owing in part to the fact that a big rental payment was due in about three weeks from the time it was started, work on the Smith well was rushed so that the lease might be given up before the payment was due if oil was not found.

On April 8th a good flow of oil was struck in the Smith well at a depth of 1,030 to 1,056 feet. The well began to flow at a rate of 100 barrels or more a day before it was shot. The news spread rapidly and within twenty-four hours there were scores of oil speculators and operators in Carlyle. It was conservatively estimated that over 500 people paid a visit to the new well on Sunday, April 9th. During the following week rains checked travel, but the hotels in Carlyle were crowded to their utmost capacity and many men went to the neighboring towns.

particularly to Beckemeyer, for hotel and livery accommodations. The crowd included leasers, operators, contractors, drillers, and a multitude of "floaters" without any special calling. Citizens were besought for sleeping accommodations; campers, usually with poor equipment, went to the river bank and roadsides, and many slept on the courthouse lawn.

During the first few weeks of the boom the main feature of the oil business was the scramble for leases. Bonus prices bounded up to more than a hundred dollars an acre for land that could have been bought outright a few months before at not more than fifty dollars an acre.

By the last of April twenty drilling outfits were on the ground and several railway oil tanks had been filled and shipped from Beckemeyer.

Many land owners were slow about leasing, and a variety of means were used to pursuade and coerce them. It is said that one farmer's son was paid $5.00 a day to influence his father. On the central streets of Carlyle were to be seen at all times of day groups of men negotiating with land owners or lease holders for leases, and some speculators cleared large sums of money.

But success was not in store for all. The new wells which were started were scattered over much of Clinton County, though they were more numerous near the Murphy and Smith wells. Out of sixteen prospect wells begun before the end of April, twelve turned out to be dry; but in May several good wells were brought in near the original ones and interest did not lag.

In May and June the producing territory was extended over several farms, but many dry holes were sunk in all directions from the pool and neither an extension nor a new pool was found. This brought on a reaction that inevitably follows a boom, and for a time discouragement prevailed. Prices of oil and other properties declined and many men left the region.

Nevertheless, the production of the pool increased without interruption. About the middle of June a pipe line was completed from Sandoval, and the oil, including much that had accumulated in storage tanks, was conducted to that town and thence to the refineries at Alton.

During the remainder of the summer the boundaries of the pool were extended gradually out to dry wells in all directions. To the northeast in particular the limits spread out much farther than anyone had expected. The lease on the Downewald farm, for example, would scarcely have brought a dollar an acre at the time of the depression in the early part of the summer, but by the end of October it was worth more than a hundred dollars an acre.

Topography of Carlyle Oil Field

The land surface in the vicinity of the Carlyle oil pool is nearly flat and level and stands at an average elevation of about 465 feet above sea level (see Pl. VI). There are a few knolls reaching 470 feet and several of the small stream valleys are cut below 460 feet. The Hempsen House stands a little above 470 feet, the road corner at the Schwierjohan School is 471 feet, and the northeast part of the field is almost 475 feet above sea. Just to the north and east of the pool are knolls which rise above 480 feet. To the east and west the surface slopes down toward Beaver Creek and Kaskaskia River which flow here a little over 400 feet above sea. To the south the surface has an altitude of about 465 feet.

Geology

STRATIGRAPHY

The stratigraphy of the Carlyle oil field is much the same as that already described for the region in which it lies; but that part of the section which has been penetrated by the oil wells is known in much greater detail than any part of the section in the remainder of the region (see Plates III and IV).

CHESTER GROUP

That part of the Chester group lying below the principal producing sand which has become known to the drillers as the Carlyle sand, is known from only a few wells and consists of one or more heavy sandstones (50 to 125 feet thick), interbedded with limestone and shale. The principal sandstone is known as the Cypress sandstone. The Carlyle sand is, on the whole, a soft porous, medium fine-grained sandstone of irregular thickness, and with numerous partings. Around the edges of the pool it is harder than in the center and in one or two places pinches out entirely. Above the Carlyle sand is about 30 feet of bluish shale containing in some places one or two beds of limestone and, in some places, red shale. The next hundred feet is even more variable. There is everywhere some shale at this position and generally, if not everywhere, a bed of hard limestone in the lower part and a bed of sandstone near the top. In some places most of the rock 30 to 130 feet above the Carlyle sand is limestone. The next 70 feet is predominantly shale, but there is some limestone, and in the northwestern part of the pool a heavy bed of sandstone occurs in the upper part.

POTTSVILLE SANDSTONE

The Pottsville sandstone is about 160 feet thick, and its base is about 200 feet above the Carlyle sand. It consists of several heavy beds of sandstone, separated by layers of shale. This sandstone is generally filled with salt water and hence is coming to be known as the "salt sand"; but along the northern border of the pool there is much gas and some oil in the lowermost part of this sand. Along the west side there is gas and water in this lower part. In McCabe No. 1, in the northwest corner of the pool, a flow of gas was strong enough to carry up quartz pebbles from the sand.

CARBONDALE FORMATION

The Carbondale formation which extends from the top of the Pottsville to the top of the Herrin coal (No. 6), is about 225 feet thick in the vicinity of Carlyle. A bed of sandstone which in the lower 50 feet of this formation varies in thickness from 10 to 40 feet or more, is almost everywhere present. This rock generally contains salt water and hence is commonly included by the drillers with the underlying "salt sands" (Pottsville). It differs from them in being somewhat softer and in containing a large amount of mica and other material besides quartz. Below this sandstone there is in some places a layer of limestone and almost everywhere a bed of shale separating it from the Pottsville sandstone below. The central part of the Carbondale formation is predominantly shale. In some places it is somewhat sandy and elsewhere it contains more or less lime, but beds of pure limestone are generally absent. A short distance below the Herrin coal there is generally a bed of sandstone which in the Carlyle oil field is dry; but in the vicinity of Centralia, about 15 miles east, it has in places a good showing of oil. Above this sandstone there is commonly a bed of limestone, and above the limestone is the Herrin coal (No. 6) which marks the top of the formation.

McLEANSBORO FORMATION

That part of the McLeansboro which is present in the Carlyle field extends from the top of the Herrin coal to the top of the Shoal Creek limestone of Illinois Survey reports. It consists principally of shale with a bed of limestone near the base overlying the Herrin coal, and with another limestone at the top; the latter limestone being in some places separated into two divisions. This upper limestone generally constitutes the bed rock under the surface clay and gravel and hence is used as a seat for the drive pipe.

QUATERNARY DEPOSITS

The Quaternary deposits in the Carlyle oil field consist of gravelly clay about 30 feet thick, overlain by clay (loess), almost without perceptible grit, ranging up to 20 feet thick. There is very little, if any, well-washed gravel but in some places there is sand with some pebbles which is free enough from clay to be known as quicksand. Sand lenses of this sort have made trouble in drilling and handling the drive pipe in some wells.

STRUCTURE

The structure of the rocks in the Carlyle field could be shown with little difficulty if the beds underlying the Herrin coal, including the oil sands, were all parallel to the coal. A study of well logs shows, however, that in the pool the Carlyle sand is nearly horizontal (Pl. VII), whereas the coal is highest along the north side of the field and dips most rapidly to the west and southwest. The dip to the east and southwest is gentle for a mile or more, and then becomes much greater.

Plate VII is a map which presents considerable information regarding the oil sand.

The data for this map are taken largely from drillers' records, but partly from determinations made by the writer. The map shows: (1) The location and name of each well and the character of the production. (2) The character so far as known of the oil-bearing sand with its overlying and underlying rock. (3) The depth of the sand below sea level at most of the wells and hence the structure of the sand. A row of diagrams taken in any direction gives a cross-section of the sand in that direction. The position of (1) the top of the sand, (2) top of pay, (3) bottom of pay and bottom of hole, are also shown as far as possible. The position of the sand at each well is determined from careful steel line measurements made for the placing of the shot and from the elevation of the platform of each well determined by spirit level.

Outside the field the sand dips in all directions except north, and apparently it also pinches out in all directions except to the north. The small irregularities in the position of the sand are probably not accurate, but arise out of the fact that one driller will call for example a sandy shale sandstone, whereas another driller will call the same rock shale. Some drillers even call certain limestones, shale.

COMMERCIAL CONDITIONS

PRODUCT OF THE WELLS

All of the wells of the Carlyle oil field yield gas, oil, and water, the amount of each varying considerably from well to well. The initial production of oil ranges up to 2,000 barrels a day, Murphy No. 5 having flowed about that amount in the first twenty-four hours. The average initial production is about 100 barrels and the average production after two months is about 50 barrels. A few wells on the outskirts of the pool have yielded less than 50 barrels on the start, and many have yielded between 200 and 300; the yield of the wells varies, therefore, considerably but not enormously.

The flow of gas is strong in all wells, particularly those in the north part of the pool. The exact amount of gas has not been determined in any well, and in but one well, McCabe No. 1, has the closed pressure been measured. It was said to show a pressure of about 80 pounds, but in many wells the gas is at times strong enough to lift a 500-foot column of oil and water. Several days after it was shot, Shaffer & Smather's Deter No. 2 developed enough gas to force the bailer (weighing several hundred pounds) out of the hole and up to the top of the derrick.

A few wells such as Shaffer & Smather's Deter No. 1 have yielded no perceptible water at first, but at such wells small quantities of water soon begin to appear, and in a few weeks a considerable part of the production is water.

The relation of the water to the oil has not been fully determined, but it seems that the producing sand contains both water and oil, and that to the north the sand is saturated with water. Generally the water is in the lower part of the sand and the oil in the upper part, and in no good oil well has a strong flow of water been found in the sand above the oil; but in many wells the oil is present in several pay streaks separated by more or less non-porous sand or shale and with some water. Many of the best wells have yielded from the beginning twice as much water as oil. The production of these wells does not appear to have dropped off more rapidly than any other wells, and the proportionate amount of salt water has remained about the same. It does not appear, therefore, that the pool is being flooded with salt water, though after some time such a condition may develop. It seems that oil, water, and gas are all three confined in the porous part of a layer of sandstone and that the production of the field will be limited only by the pore space in that sandstone.

The total thickness of the pay sand averages 10 or 12 feet. The pore space has not been determined but probably amounts to about 10 or 15 per cent of the rock. The total amount of oil in the pool, therefore, may be very roughly estimated to be about 10,000,000 barrels. The minimum quantity recoverable is probably over a half, and possibly three quarters or more, depending upon the movement of the water.

The gravity of most of the oil is somewhat above 33 degrees Baumé; some of it is as high as 37 or 38, and some is a little below 33 degrees. A sample from the south side of the Dieppenbrock farm was examined by Dr. David T. Day, who says that it is "well suited for refining, and is rich in good gasoline and illuminating oil," and that it is "of the

Crawford and Clark county type." This sample had a specific gravity of 0.8563 or 33.5° B. It began to boil at 105° C. Between 105° and 150° it yielded 8 c.c. of oil with a gravity of 0.7445 and between 150° and 300° yielded 33 c.c. of a specific gravity of .1016. The residuum 57.5 c.c. had a specific gravity of .9126.

The oil from wells on the edges of the pool is remarkably dark and heavy. A sample from the Schulte farm at the southwest corner of the field yielded upon analysis only half as much gasoline and a third as much kerosene as the oil from within the pool, and it showed the oil to be unsuitable for ordinary refining purposes.

There is a rather large amount of waste oil, but this is steamed and the part now actually wasted appears to be less than one per cent of the whole production. The waste oil is burned at considerable expense in open pools and ditches.

COSTS

The price of leases includes about a dollar an acre as annual rental, and one-eighth of the oil and gas produced. In addition to this a "bonus" is commonly paid, the amount varying from a few cents to several hundred dollars an acre, according to the probability of getting oil. The leasers receive either a salary or a commission varying from one to ten cents an acre for the leases they secure. The contractor's price for drilling is now $1.10 to $1.25 per foot, but was more at first on account of uncertainties regarding the character of the strata. It is greater in the case of deep wells, such as those which have been drilled over 2,000 feet, for which the contract price is about $2.00 per foot. The contractor bears the expense of everything but the casing and the shooting. He pays $5.00 a day for fuel, $3.00 a day for water, about $6.00 a day to each of his drillers, and $5.00 to each of the tool dressers. After drilling is completed the contractor receives about $20.00 a day for cleaning out the well. Pumps, power houses, and tanks constitute a large item of expense, and the upkeep of the wells involves a considerable outlay. Each lease has its power houses from which all the wells are pumped by means of "jacks." After drilling is completed, three or four men, including farm boss and pumpers, are given steady work on each lease.

METHOD OF GETTING AND HANDLING THE OIL

The drilling apparatus used includes many kinds of machines—Star, Parkersburg, National, and others—and both turnbuckle and standard rigs. To the drillers the standard and turnbuckle rigs are most desirable, but many contractors prefer machines because of the smaller initial outlay and the lower expense of moving. The drillers and tool dressers work twelve-hour tours, changing at noon and midnight.

Four sizes of casing are used. The drive pipe is twelve and a half inches in diameter and about 50 or 60 feet long in order to reach the first hard rock. In some places where the upper limestone (Shoal Creek limestone of Illinois Survey reports) is absent, over a hundred feet of drive pipe have been used. Ten-inch pipe is used to hold the soft shales of the Carbondale and McLeansboro formations out of the hole and is about 650 feet long. Eight hundred and fifty feet of eight-inch casing are used to shut off the water from the Pottsville ("salt sands"). The smallest casing is six and a quarter inches in diameter. This holds back the soft shales of the Birdsville formation which would otherwise cave in and seriously hinder drilling in the oil sand. Over one thousand feet of this size are used.

Upon reaching the pay sand, drilling is continued with much care in order to make sure of stopping before the oil is passed and water-bearing rock tapped; but in order to be certain of having penetrated all the productive part of the sand, most wells are drilled until there are signs of increasing water or a change in the character of the sand.

The wells are shot as soon as convenient after being finished. The amount of nitroglycerine used is generally about forty quarts, though in some wells with a poor showing of oil and a close, hard sand, as much as a hundred or more quarts have been used. The shot is commonly anchored a foot or more above the bottom and is sometimes set off by the electric spark and sometimes by dropping a dynamite cartridge with a fuse, into the hole. Before the shot is fired, the smallest casing is pulled and if the well promises to be a heavy producer, lead lines are made ready and connected so that only the first flow of oil is lost. If there is not a large showing of oil before the well is shot, lead lines are generally not needed until the hole has been cleaned.

Most of the wells flow within ten minutes after the explosion, but many of them "bridge over," and do not develop enough pressure to break the bridge. Indeed, Murphy No. 5, the heaviest producer in the field was so effectually plugged by the shot, that it was thought to be below the average until the tools were let down and the bridge broken.

After the shot, the best wells flow intermittently ("by heads") for several weeks. One well, Schomaker No. 1, had been flowing over four months at the time this examination was made. The lighter wells are "put to pumping" within a few days after being shot.

The oil goes first to a tall, slender "gun barrel" tank where most of the water settles to the bottom and flows out automatically. The oil is then conducted to a tank where it is steamed to separate more water from the oil. Finally, after the waste oil has settled, been drawn off, and the gager has measured the amount of oil, the tanks are opened and the oil is forced into pipe lines by means of small steam engines.

ACCIDENTS

Several more or less serious accidents have occurred. One man was badly burned at the Bond well engine and several have received somewhat painful injuries while unloading casing. Two men have been seriously injured by blown-off well caps.

FIRE LOSSES

There has been but one important fire in the Carlyle field. This one, on the eighty of the Deter farm was caused by a waste oil fire which became uncontrollable. Several tanks of oil and one drilling outfit were destroyed, entailing a loss of several thousand dollars.

WELL RECORDS

The following records have been chosen as representative of the wells in the Carlyle pool and surrounding territory:

WELLS IN THE CARLYLE FIELD

Well No. 4 on Henry Wilkins farm

Location—SE. ¼ sec. 10, T. 2 N., R. 3 W.

Altitude—465 feet.

Description of Strata	Thickness Feet	Depth Feet
Clay, sand and gravel, containing some peat, water, and gas	130	130
Shale	20	150
"Shell"	10	160
Shale	20	180
Sandstone (water)	15	195
Shale	35	230
"Shell"	10	240
Shale	110	350
Limestone	20	370
Shale	20	390
"Shell"	30	420
Shale	15	435
Coal	2	437
"Slate and shells'	243	680
Sandstone (salt water)	20	700
Shale	45	745
"Shell"	15	760
Shale	55	815
"Cave"	25	840
Limestone	30	870
Shale	20	890
Limestone	60	950
Shale	15	965
Limestone	20	985
Shale	19	1,004
"Shell"	14	1,018
Shale	5	1,023
"Shell"	3	1,026
Shale	3	1,029
Sandstone (dry)	17	1,046
Sandstone (oil)	11	1,057

Well No. 2 on NE. part of Deter farm

Location—SW. ¼ NE. ¼ sec. 2, T. 2 N., R. 3 W.
Altitude—465 feet.

Description of Strata	Thickness Feet	Depth Feet
Clay	42	42
Limestone	8	50
Shale	210	260
Limestone	8	268
Shale	92	360
Red rock	10	370
Limestone	6	376
Shale	34	410
Limestone	5	415
Coal	5	420
Shale	15	435
Limestone	45	480
Shale	70	550
Limestone	3	553
Shale	37	590
Red rock	20	610
Shale	86	696
Sandstone (salt water)	81	777
Shale	63	840
Sandstone, show of gas[a]	10	850
Sandstone and limestone	5	855
Shale	27	882
Limestone	43	925
Shale	20	945
Limestone	35	980
Shale	15	995
Limestone	5	1,000
Shale	23	1,023
Shale, sandy	11	1,034
Sandstone, show of oil	1	1,035
Sandstone	6	1,041
Sandstone (oil)	5	1,046
Sandstone (oil and gas)	6	1,052

[a]In the No. 1 well on this lease 400 feet from No. 2 salt water and gas were found in this sand in such quantities that drilling was stopped for four hours.

Well No. 6 on Smith farm

Location—NW. ¼ NW. ¼ sec. 11, T. 2 N., R. 3 W.
Altitude—468 feet.

Description of Strata	Thickness Feet	Depth Feet
Soil	8	8
Gravel and sand	17	25
Gravel	42	67
Lime	20	87
Shale, hard	113	200
Shale	200	400
Limestone	5	405
Shale, hard	5	410
Limestone	20	430
Coal	6	436
Shale, hard	45	481
Sand and water	10	491

Shale, black	34	525
"Slate"	45	570
Sandstone	5	575
"Slate"	10	585
Coal	3	588
Shale, black	22	610
"Slate"	10	620
Sandstone	19	639
"Slate"	36	675
Sandstone (salt water)	48	723
Shale	4	727
Sandstone (salt water)	31	758
Shale	10	768
"Slate"	12	780
Sandstone and shale	20	800
"Slate"	68	868
"Shell"	4	872
Sandstone and shale	18	890
"Slate"	15	905
Sandstone (salt water)	12	917
"Slate"	43	960
Limestone	12	972
"Slate"	10	982
Limestone	53	1,035
Sandstone and shale	8	1,043
"Slate"	5	1,048
Sandstone	18	1,066

Well No. 1 on the McCabe farm

Location—SW. ¼ NE. ¼ sec. 3, T. 2 N., R. 3 W.
Altitude—464 feet.

Description of Strata	Thickness Feet	Depth Feet
Soil	5	5
Clay, sandy	56	61
Shale	319	380
Limestone	11	391
Shale	8	399
Coal	12	411
"Slate"	165	576
Sandstone (salt water)	15	591
Shale	25	616
Sandstone (salt water)	94	710
Shale and sandstone	130	840
Shale	10	850
Sandstone (gas)	20	870
Sandstone (oil)	35	905
Shale	45	950
Limestone	48	998
Shale	23	1,021
Sandstone (gas)	13	1,034
Sandstone (oil)	19	1,053

Well No. 1 on Karhoff farm

Location—NE. ¼ NW. ¼ sec. 10, T. 2 N., R. 3 W.
Altitude—469 feet.

Description of Strata	Thickness Feet	Depth Feet
Soil	25	25
Gravel	10	35
"Hard pan"	35	70
Gravel (water)	5	75
Limestone	7	82
Shale	118	200
Limestone	35	235
Shale	165	400
Limestone	5	405
Shale	10	415
Limestone	5	420
Coal	6	426
Shale	164	590
Limestone	10	600
Shale	114	714
Sandstone (salt water)	15	729
Shale	31	760
Sandstone (salt water)	30	790
Shale	5	795
Limestone	5	800
Shale	30	830
Limestone	10	840
Shale	40	880
Limestone	5	885
Shale	10	895
Limestone	25	920
Shale	10	930
Limestone	10	940
Shale	72	1,012
Limestone	13	1,025
Shale	13	1,038
Sandstone (oil)	21	1,059
Shale	16	1,075
Limestone	7	1,082
Shale	3	1,085
Limestone	12	1,097
Shale	3	1,100

Well No. 1 on Treat-Crawford Deter lease

Location—SE. ¼ SW. ¼ sec. 2, T. 2 N., R. 3 W.
Altitude—472 feet.

Description of Strata	Thickness Feet	Depth Feet
Clay and gravel	56	56
Limestone	6	62
"Slate and shells"	375	437
Limestone	1	438
Coal	7	445
Shale	224	669
Limestone	10	679
Shale	35	714
Sandstone (salt water)	39	753

Shale	12	765
Sandstone (salt water)	11	776
Shale	17	793
Sandstone (salt water)	5	798
Shale	22	820
Limestone	8	828
"Slate and shells"	127	955
Limestone	2	957
Sandstone	8	965
"Slate and shells"	63	1,028
Limestone	16	1,044
Sandstone	2	1,046
Sandstone and shale	3	1,049
Sandstone (gas)	4	1,053
Sandstone (oil)	5	1,058
Shale	2	1,060
Sandstone (oil)	4	1,064

WELLS OUTSIDE THE CARLYLE FIELD

Well No. 1 on Holthaus farm

Location—SE. ¼ SE. ¼ sec. 29, T. 2 N., R. 3 W.
Altitude—440 feet.

Description of Strata	Thickness Feet	Depth Feet
Drift	78	78
Shale	40	118
Limestone	6	124
Shale	32	156
Limestone	3	159
Shale	52	211
Coal	5	216
Shale	53	269
Limestone	6	275
Shale	35	310
Limestone	4	314
Shale	20	334
Limestone	12	346
Shale	16	362
Limestone	43	405
Coal	11	416
Shale	4	420
Limestone	35	455
Shale	24	479
Coal	3	482
Shale	30	512
Limestone	12	524
Shale	23	547
Sandstone	24	571
Shale	26	597
Sandstone (salt water)	43	640
Shale	12	652
Sandstone (salt water)	55	707
Shale	8	715
Sandstone (salt water)	34	749

Shale	20	769
Sandstone	12	781
Limestone	8	789
Sandstone and shale	18	807
Shale	12	819
Sandstone (salt water)	10	829
Shale	4	833
Limestone	44	877
Red rock	3	880
Shale	5	885
Limestone	20	905
Shale	26	931
Red rock	10	941
Shale	20	961
Limestone	25	986
Shale	14	1,000
Sandstone	10	1,010
Shale	12	1,022
Sandstone (salt water)	38	1,060
Shale	12	1,072
Limestone	8	1,080
Shale	20	1,106
Limestone	8	1,108
Shale	6	1,114
Red rock	4	1,118
Limestone	12	1,130
Red rock	15	1,145
Sandstone (salt water)	20	1,165
Shale	5	1,170
Sandstone (salt water)	50	1,220
Shale	5	1,225
Limestone	10	1,235
Sandstone (salt water)	53	1,288

Well No. 2 on A. Beckemeyer farm

Location—NE. ¼ NW. ¼ sec. 22, T. 2 N., R. 3 W.
Altitude—455 feet.

Description of Strata	Thickness Feet	Depth Feet
Soil	5	5
Sand and gravel	50	55
Limestone	15	70
"Slate"	70	140
Limestone	10	150
Shale	150	300
Limestone	8	308
"Slate"	67	375
Shale	60	435
"Slate"	4	439
Coal	6	445
Clay	10	455
"Slate"	165	620
Sandstone (salt water)	10	630
"Slate"	60	690

Sandstone (salt water)	90	780
Shale	20	800
Sandstone	20	820
Shale	5	825
Sandstone	10	835
Limestone	30	865
Sandstone (salt water)	35	900
Shale	10	910
Limestone	10	920
Shale	20	940
Limestone	15	955
Shale	5	960
Limestone	35	995
Shale	15	1,010
Limestone	18	1,028
Sandstone (salt water)	51	1,079
Shale	5	1,084

THE CARLINVILLE OIL AND GAS FIELD

By Fred H. Kay

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THE CARLINVILLE OIL AND GAS FIELD

INTRODUCTION

This paper is a preliminary report on the Carlinville oil and gas field, and is designed to meet the needs of operators who are attempting to locate the most favorable areas for the accumulation of oil and gas. Data are too meagre at the present time for the deduction of final conclusions regarding the possibilities of the field, but it is hoped that this presentation of available information will be of some use in pointing out the geologic structure of the field, and thereby limiting prudent exploration to the most favorable localities.

Acknowledgments are due to the operators who have freely submitted information regarding their wells, and especially to Mr. Thomas Rinaker for hearty cooperation, and for the use of a large number of data in his possession.

This report is an amplification of one made by Mr. R. S. Blatchley in Bulletin 16 of the State Geological Survey, 1910, and is based on more recent data than were available when Mr. Blatchley made his investigation of this field.

LOCATION AND EXTENT

The Carlinville oil and gas field is near Carlinville, Macoupin County, Illinois. Up to December 1, 1911, twenty-five wells had been drilled within a radius of five miles from town. The productive area, however, is three miles southwest of Carlinville in secs. 7 and 8, T. 9 N., R. 7 W., as shown by Plate VIII.

The recent discovery of a commercial quantity of oil in addition to the gas for which the field has heretofore been known has stimulated interest, and has encouraged operators to undertake further prospecting.

Not enough drilling has been done to outline the productive field, but the principal wells lie in an elliptical area, the main axis of which is about one mile in length, extending from the central-eastern part of sec. 7, northeast into sec. 8. The minor or north-south axis is about one-quarter mile in length, drilling having been confined to the flood plain of Macoupin Creek.

HISTORY

The first drilling in this field was done about 1867 by St. Louis capital. One well was put down without striking oil and was abandoned. No further efforts were made until 1909, when the Impromptu Exploration Company drilled several wells and developed enough gas for illuminating purposes in the town of Carlinville.

Although most of the drilling has been done by the Impromptu Exploration Company, the following operators have put down one or more holes: E. E. Chrysler; C. J. Lumpkin and associates; John Dunn; Andrew Benson; Ohio Consolidated Oil Co.; E. A. Ibbetson.

TOPOGRAPHY

Relief

The Carlinville area is one of moderate relief. The upland prairies are level or gently rolling, and in most cases are less than 100 feet above the valley floors of the larger streams. The topography becomes rugged near the valleys of the principal drainage lines, and although the relief is not great, it is sufficient to characterize the wooded hills bordering the valleys as the "broken country."

No precise levels have been run in this district by the Survey, and for the present report Carlinville is considered to be 664 feet above sea level, this being the elevation given by the Chicago & Alton Railroad for their station.

Drainage

The main drainage line is Macoupin Creek, which flows southwest through the district. This creek and its tributaries have cut valleys about 100 feet below the general level of the country, and the main flood plain, upon which most of the drilling has been done, is wide enough to be a conspicuous feature of the topography. At times of high water a large area bordering Macoupin Creek is submerged, and sometimes, especially in the spring, surface water covers the casings and fills the wells. Run-off is rapid, however, and drilling operations are not often interrupted for any considerable time.

GEOLOGY

Stratigraphy

GLACIAL DRIFT

Most of the bed rock in the Carlinville field is covered by a variable amount of clays, sands, and gravels which constitute the glacial drift. The thickness of this material varies in different parts of Macoupin County from a thin covering up to 200 feet, the irregularity being due to the uneven character of the surface upon which the drift was deposited. The extreme thicknesses, such as those of 200 feet, are probably the result of the filling of pre-glacial valleys. Macoupin Creek and its tributaries have carried away much of the surface material along their channels, and in some places have exposed the underlying rocks.

"COAL MEASURES" ROCKS

GENERAL DESCRIPTION

All of the stratified rocks exposed in the Carlinville field belong to the series known as the "Coal Measures." Although the series as a whole may be described as consisting of shales, sandstones, a minor amount of limestone and several beds of coal, it is usually impossible to correlate individual beds in different well logs with any degree of exactness. Three horizons—the Carlinville limestone, coal No. 6, and the oil and gas zone at the base—are persistent, but the intervening shales, although constant in thickness, are changeable in character.

The rocks above the oil sands in the Carlinville field have been divided by geologists into two parts, the name McLeansboro being assigned to the beds from the first solid rock near the surface, down to the top of coal No. 6. The beds above the oil sands up to and including coal No. 6 are known as the Carbondale formation.

The Carbondale varies in thickness from 200 to 250 feet; and since the McLeansboro was subject to erosion in pre-glacial times, its thickness is even more variable. Best No. 1 and Sellers No. 1 showed 200 feet of this formation, but the average for the field is lower. Barnstable No. 1 penetrated 550 feet of "Coal Measures" rocks. This figure is from 50 to 100 feet in excess of that for a majority of the wells in the Carlinville field. The following section gives a general idea of the position and thickness of the upper part of the "Coal Measures" strata.[1]

Record of Weir's shaft, Carlinville

Description of Strata	Thickness Feet	Depth Feet
Drift clays	75	75
Shale, soft	28½	103½
Coal, soft	½	104
Fire clays, dark and light	5	109
Sandstone and shale	70	179
Clay shale	15	194
Shale, dark	6	200
Coal, soft, smutty	5	205
Fire clay	6	211
Sandstone	8½	219½
Clay shale	2	221½
Limestone	3	224½
Clay shale	1	225½
Limestone	1½	227
Coal	1½	228½
Shale	6½	235
Coal	½	235½
Fire clay	2½	238
Hard rock (probably limestone or limy sandstone)	12	250
Shale	5	255
Limestone	5	260
Shale, black	4	264
Coal, No. 6	6	270

[1]Worthen, A. H., Geol. Survey of Illinois, vol. V, p. 289, 1873.

CARLINVILLE LIMESTONE

No. 11 of the section is a seven-foot bed of hard, gray limestone known as the Carlinville. This limestone, which is frequently exposed, and which forms the bed rock in most of the field, has been traced from the vicinity of La Salle, Ill., south to Carlinville, thence southeast into Saline County. Because of its occurrence over this large area, it constitutes a useful key horizon in any attempt to determine the structural geology of the field. Its absence in some of the wells is due, no doubt, to erosion prior to the deposition of the glacial material.

The following detailed sections of the Carlinville limestone are taken from a report by Mr. J. A. Udden.[1]

Exposures on the Walker farm NE. ½ sec. 35, T. 10 N., R. 7 W.

		Feet
3.	Limestone, chocolate colored, coarse grained, in beds ½ to 6 inches in thickness	3½
2.	Shales, gray	10
1.	Limestone, very hard, bluish gray, in seams varying from 3, 8, to 12 inches; brown on weathering	2

In the NW. ¼ sec. 31, T. 10 N., R. 7 W., the same limestone as bed No. 1 of the section given above, occurs with a thickness of 6 feet. It is exposed on the east side of Spanish Needles Creek in the NW. ¼ sec. 21, T. 9 N., R. 7 W., and in a small tributary to this creek in the NW. ¼ sec. 28, T. 9 N., R. 7 W. It outcrops at a few places in the channel of Macoupin Creek. Mr. Udden says: "The Carlinville limestone averages about seven feet in thickness. It is generally bluish gray, compact, close textured, and very hard, breaking into irregular pieces. On weathering it assumes a rusty color. Two features are characteristic of this limestone, one, a blotchy appearance and the other its tendency to weather into seams two and one-half to three inches in thickness." About 15 feet above the Carlinville limestone and overlying gray shales, a 4-foot bed of coarse-grained, chocolate-colored limestone occurs, which in some places has the appearance of a sandstone because of the presence of sands grains and flakes of mica. This limestone disintegrates easily, and can usually be distinguished without difficulty from the harder Carlinville bed.

COAL NO. 6

Although several coal horizons are usually penetrated by the drill, only No. 6 holds its thickness and general characteristics over a considerable area. This coal, which averages about 6½ feet in thickness, occurs 200 to 220 feet below the Carlinville limestone. Some of the wells, such as Klein No. 1, V. Hall No. 5, McClure No. 1, and M. F. Hall

[1]Udden, J. A., The Shoal Creek limestone: Ill. State Geol. Survey, Bull. 8, p. 120, 1907.

No. 1, show no coal. It is possible that in some cases black shale represents the coal horizons, but it is most probable that the absence of coal is due to erosion prior to the deposition of the glacial drift.

The sands vary in thickness from a few feet to about seventy feet and are believed to constitute the Pottsville formation, lying at the base of the "Coal Measures."

MISSISSIPPIAN ROCKS

Underneath the sands, the drill usually strikes limestone which is supposed to be either Ste. Genevieve or St. Louis limestone of Mississippian age, although no samples of this formation have been examined. The Chester shales, sandstones, and limestones, which underlie the State south of Carlinville, and which include most of the producing sands of the main oil fields, are absent in this field. This signifies that while the Chester beds were being deposited to the south, the Carlinville area was a land surface, subject to erosion. The fact that the Pottsville beds were afterward deposited upon an uneven surface, accounts for some of the irregularities in the thickness of the sands. The log of F. Hall No. 1 in the W. ½ SW. ¼ sec. 5, T. 9 N., R. 7 W., furnishes the deepest record in the field and is published herewith:

Record of F. Hall well, No. 1

Location—W. ½ SW. ¼ sec. 5, T. 9 N., R. 7 W.

Elevation—655 feet above sea level.

Description of Strata	Thickness Feet	Depth Feet
Surface	40	40
Soapstone	38	78
"Slate"	137	215
Limestone, white	8	223
Shale, black and coal	10	233
Lime shell	4	237
"Slate," white	6	243
Lime	8	251
"Slate," white	39	290
Coal	3	293
"Slate," white	57	350
Shale, brown	8	358
"Slate," white, sandy	137	495
Sand, coarse (gas?)	10	505
Sand, soft, salt water	65	570
Lime, sandy, hard (fresh water at 700)	156	726
Sand, salt	5	731
Limestone, hard	24	755
Water sand	20	775
Limestone	25	800
Limestone and shale	13	813
Limestone and sand	25	838
Limestone, broken	32	870
Limestone, brown	15	885
Limestone, black (iron pyrites)	10	895
Sand, gray	25	920

Shale	48	968
Limestone, sandy (salt water)	247	1,215
Limestone, red and brown	10	1,225
Limestone, gray	25	1,250
"Slate," light colored	50	1,300
Limestone, brown	8	1,308
"Slate," black, gritty	87	1,395
Limestone	160	1,555
Sandstone	45	1,600
Unrecorded	135	1,735
"Slate," white	179	1,914
Lime (water almost fresh)	193	2,107

Structure

Since most of the rocks are covered by a mantle of glacial drift, the arrangement of the beds and the "lay" of the sands must be determined by a study of the well logs. The map which accompanies this report (Pl. VIII) shows contour lines drawn with a ten-foot interval, connecting those points on the top of the oil sands which have the same elevations above sea level. The elevations of the wells were determined by stadia surveys and the altitude of the oil sands were obtained by subtracting from the well elevation, the amount of material above the sands, as shown by the well logs.

The present wells roughly outline a fold of considerable intensity but of small areal extent. The apex or highest point is probably reached by Klein No. 1, located in the NE. ½ SE. ¼ sec. 7. In it the sand occurs 238 feet above sea level, or more than 100 feet higher than the corresponding sands in Klein No. 2, which is but one-half mile south. The general shape of the fold resembles the bowl of an inverted spoon, its longest axis extending about N. 60° E. from the center of the eastern half of sec. 7, T. 9 N., R. 7 W.

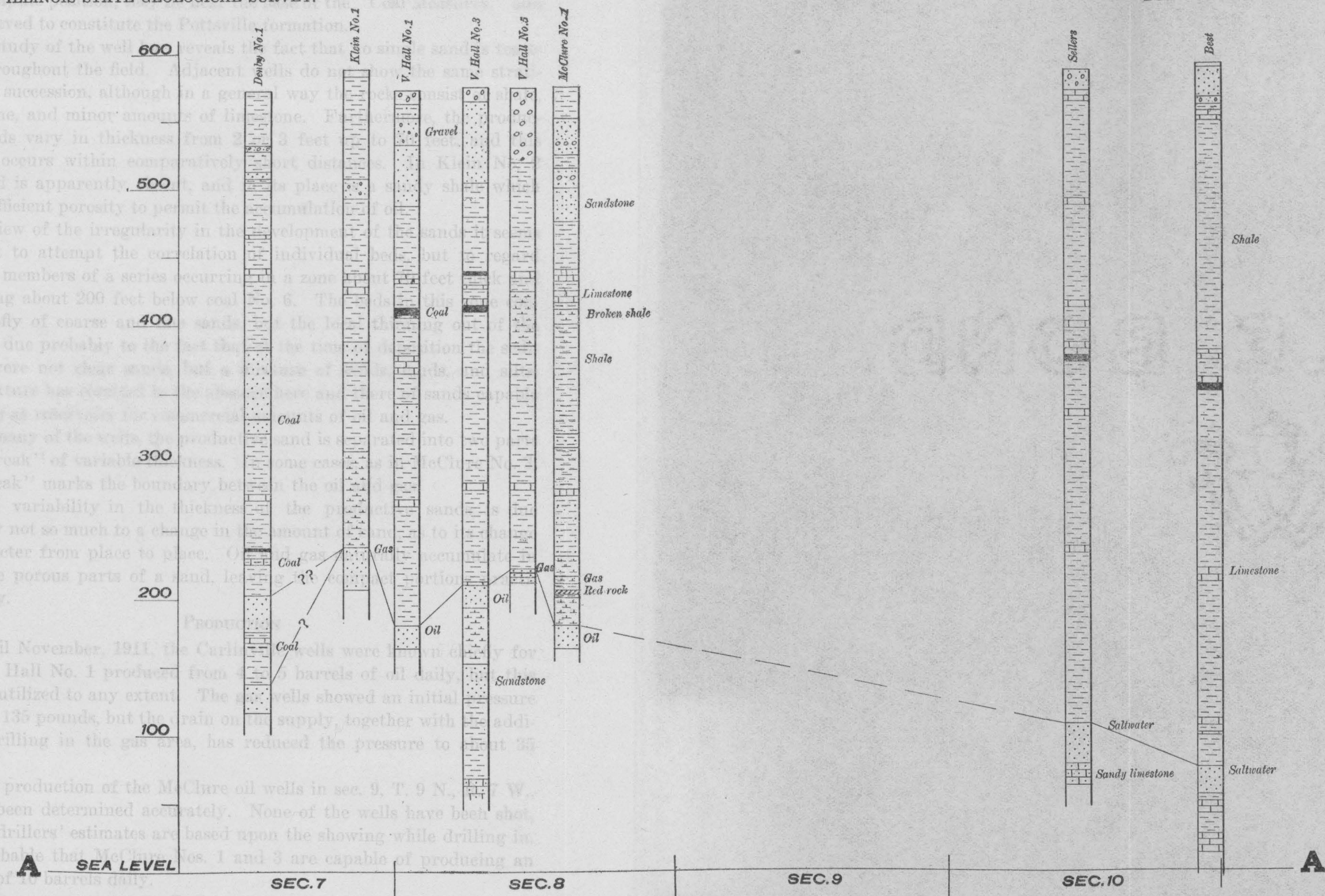
Plates IX and X indicate the dips along lines A-A and B-B of Plate VIII. From Klein No. 1, the strata dip steeply to the north, west and south, but more gently to the east. In Hall No. 5, near the center of sec. 8, the productive sands are found only 24 feet lower than those in Klein No. 1. East of Hall No. 5 the sands show a dip of 34 feet to McClure No. 1, which is 600 feet distant. No accurate information is available for the territory east of the McClure wells, except the logs of Sellers No. 1 in the SE. ¼ NW. ¼ sec. 10, and Best No. 1, in the NE. ¼ sec. 10. In the former the sands were found at 107 feet above sea level, and in the latter, at 76 feet; thus showing a continuation of the general dip noted in the E. ½ sec. 8.

OIL AND GAS

Sands

Although the productive sands are not invariably found at the same

ILLINOIS STATE GEOLOGICAL SURVEY. BULL. NO. 20, PLATE IX.



Structure section from west to east through Carlinville field.
(For location see Plate VIII.)

stratigraphic position, they lie near the base of the "Coal Measures," and are believed to constitute the Pottsville formation.

A study of the well logs reveals the fact that no single sand is traceable throughout the field. Adjacent wells do not show the same stratigraphic succession, although in a general way the rocks consist of shale, sandstone, and minor amounts of limestone. Furthermore, the producing sands vary in thickness from 2 or 3 feet up to 70 feet, and this change occurs within comparatively short distances. In Klein No. 2 the sand is apparently absent, and in its place is a sandy shale which lacks sufficient porosity to permit the accumulation of oil.

In view of the irregularity in the development of the sands it seems best not to attempt the correlation of individual beds, but to regard them as members of a series occurring in a zone about 70 feet thick and beginning about 200 feet below coal No. 6. The beds in this zone consist chiefly of coarse and fine sands, but the local thinning out of the sands is due probably to the fact that at the time of deposition the sediments were not clear sands, but a mixture of sands, muds, and silts. This mixture has resulted in the absence here and there of sands capable of acting as reservoirs for commercial amounts of oil and gas.

In many of the wells, the productive sand is separated into two parts by a "break" of variable thickness. In some cases, as in McClure No. 3, the "break" marks the boundary between the oil and gas.

The variability in the thickness of the productive sands is due probably not so much to a change in the amount of sand, as to its change in character from place to place. Oil and gas naturally accumulate in the more porous parts of a sand, leaving the compact portions practically dry.

Production

Until November, 1911, the Carlinville wells were known chiefly for gas. V. Hall No. 1 produced from 4 to 5 barrels of oil daily, but this was not utilized to any extent. The gas wells showed an initial pressure of about 135 pounds, but the drain on the supply, together with the additional drilling in the gas area, has reduced the pressure to about 35 pounds.

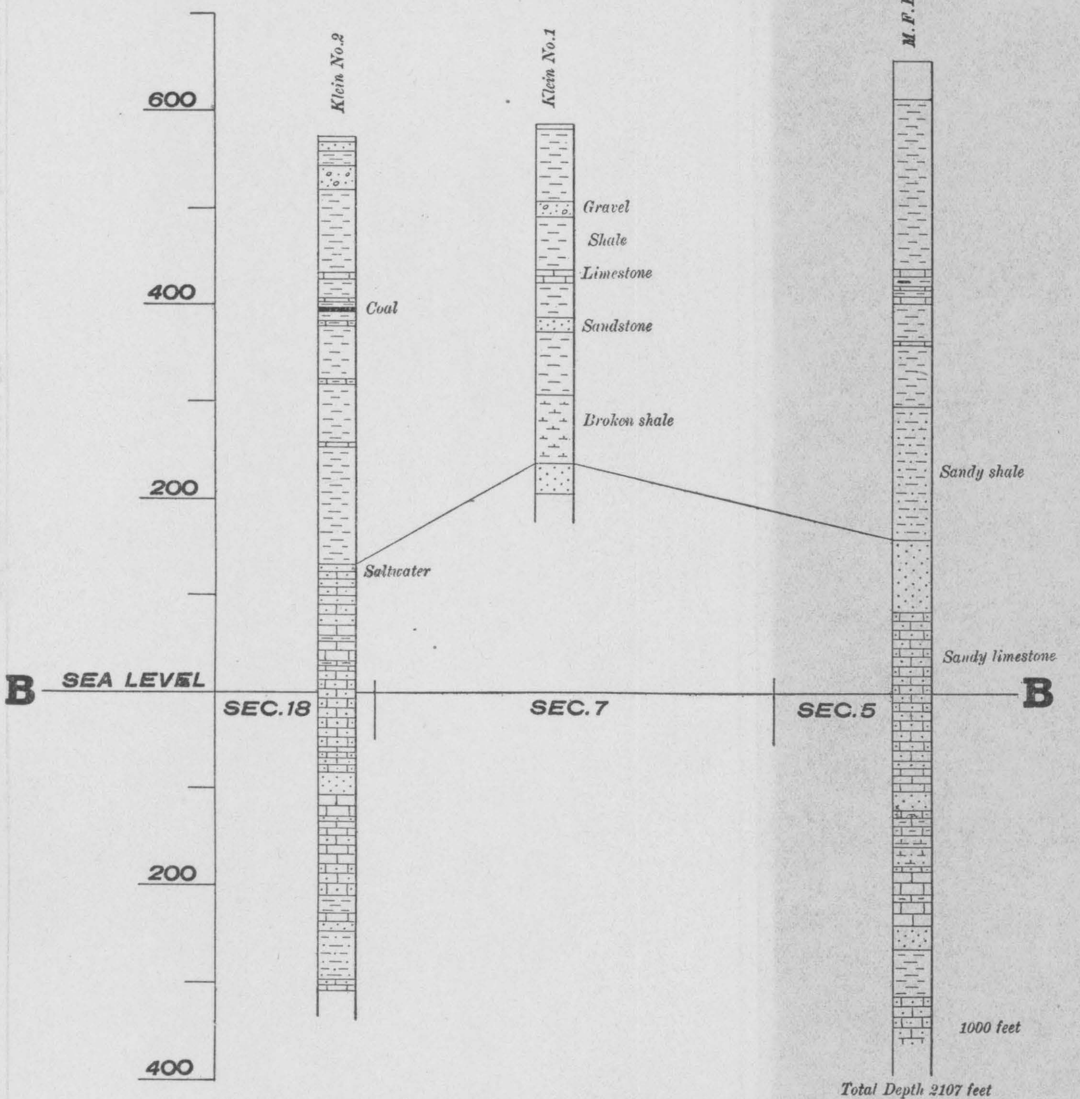
The production of the McClure oil wells in sec. 9, T. 9 N., R. 7 W., has not been determined accurately. None of the wells have been shot, and the drillers' estimates are based upon the showing while drilling in. It is probable that McClure Nos. 1 and 3 are capable of producing an average of 10 barrels daily.

Development

Table 34 shows the development in the Carlinville field, and contains well data gathered from various operators and drillers:

TABLE 34.—*Partial record of Carlinville wells*

Name	Location	Altitude	Strata	Depth to top	Thickness	Remarks
				Feet	*Feet*	
Barnstable No. 1	NE. ¼ SE. ¼ sec. 7, T. 10 N., R. 7, W	610	Salt sand	547	....	Bottom 550. Rainbow of oil. Small amount gas in salt water at 547
Walker No. 1	NW. ¼ sec. 35	590?	Coal	208	7	Bottom 447
			do	335	5	
			Gas sand	397	8	
Walker No. 2	NW. ¼ sec 35	590?	Coal	220	5	Bottom 535. No gas
			Salt sand	510	15	
F. Hall No. 1	W. ½ SW. ¼ sec, 5, T. 9 N., R. 7 W.	655	Coal	290	3	Bottom 2107
			Sand, coarse	495	10	
			Salt sand	505	65	
E. W. Denby No. 1	NE. ¼ SW. ¼ sec. 7	572	Coal	160	Streak	Bottom 455. Little gas at 160
			Coal	241	Streak	
			Coal	335	2 feet.	
			Coal	404	Streak	
			Salt sand	369	27	
			Salt sand	434	21	
			Carlinville lime	130	....	
Klein No. 1	NE. ¼ SE. ¼ sec. 7	588	Gas sand	350	31	Bottom 381. Initial pressure 135 pounds
Klein No. 2	E. ½ NE. ¼ sec. 18	573	Coal	175	5	Bottom 880 in limestone. Salt water at 450 charged with gas
			Sand and salt water	465	38	
V. Hall No.1	NW. ¼ SW. ¼ sec. 8	572	Coal	160	5	Bottom 409 in 17 feet sand. Gas in shale at 373. Oil at 388. Average 4 bbls.
V. Hall No. 3	SE. ¼ NW. ¼ sec. 8	574	Coal	135	3	Bottom in sandy lime at 506
			Coal	160	5	
			Gas sand	364	7	
			Water sand	371	10	
			Oil sand	376	5	
V. Hall No. 5	SE. ¼ NW. ¼ sec. 8	574	Sand, show of oil	353	2	Bottom 363. Fine water sand. Salt water and rainbow of oil
			Sand, brown	355½	4	
			Sand fine, gas	359½	3	
McClure No. 1	SW. ¼ NE. ¼ sec. 8	574	Oil sand	394	16+	Bottom 410. Good pay. Estimated 10-15 bbls. No salt water
McClure No.2	SW. ¼ NE. ¼ sec. 8	574	Gas sand	373	3	Abandoned at 376. Crooked hole
			Shale gas	347	....	
McClure No. 3	SW. ¼ NE. ¼ sec. 8	574	Gas sand	377	13	Bottom 412. Sand with small amount salt water. Estimated 10-15 bbls
			Slate	390	4	
			Oil sand	394	16	
McClure No. 4	SW. ¼ NE. ¼ sec. 8	576	Gas sand	350	10	Bottom 419. Sand broken. Small amount oil and gas. Best show 405-410
			Gas sand	378	11	
			Oil sand	405	11	
Sellers No. 1	SE. ¼NW. ¼ sec. 10	587	Coal	210	5	Bottom 525
			Salt sand	480	29	
			Carlinville lime	15	....	



Structure section from south to north through Carlinville field.
(For location see Plate VIII.)

Best No .1......	NE. ¼ NE. ¼ sec. 10.............	591	Coal................	240	5	Bottom 578. Show of oil 516........
			Salt sand	515	20	
			Carlinville lime.......	35	....	
Haacke No. 1....	SW. ¼ SE. ¼ sec. 17.............	577	Coal................	172	5	Bottom in sand at 450. Show of oil in black slate 392-410. Oil 417 (small amount.) Salt water 421..........
			Sand...............	389	61	
D. Denby No. 1..	SW. ¼ SE. ¼ sec. 17.............	585	Coal................	395	3	Bottom 536. Dry..................
			Sand, show oil......	417	5	
			Sand, white and blue.	422	7½	
			Salt water in sand...	465	50	
Griffell No. 1....	NW. ¼ SE. ¼ sec. 15.............	718	Coal................	365	5	Bottom in lime 655................
			Sand, salt water.....	631	12	
Hammann No. 1..	NE. ¼ SE. ¼ sec. 28.............	590?	Sand...............	509	6+	Bottom 515. Small amount gas in upper part of sand................
			Salt water..........	515	....	

Character of Oil and Gas

The gas is of good quality. It has little odor and burns with a hot, blue flame. Mr. Rinaker reports that the gas in Klein No. 2 was noted only as it was liberated from the slightly brackish water bailed from the lower part of the well. When ignited at the top of the bailer, the gas burned with a faint bluish flame and with an odor resembling alcohol. The water freed from the gas settled as much as two feet in the bailer.

The oil is dark brown by transmitted light and nearly black by reflected light. Two samples from V. Hall No. 1 and McClure No. 3 have a specific gravity of 28.6° Baumé. The oil is similar in physical respects, to that at Duncanville, Illinois, which is utilized almost entirely as fuel.

Relation of Oil and Gas to Structure

It is generally assumed when oil and gas occur near the top of a dome, as at Carlinville, that they are held in position by the salt water below. If this were not true the oil would settle of its own weight into the lowest parts of the productive sand.

In case the oil is not sufficiently abundant to saturate the sands above the level of salt water, the gas occupies the crest of the dome above the oil. The latter, resting on the salt water below, holds an intermediate position and, in most cases, is charged with gas from above because of the great pressure exerted by the underlying water.

The Carlinville dome, although irregular in shape, appears to conform in general to the ideal dome. The gas wells are located at or near the crest of the fold. Klein No. 1 in the E. ½ SE. ¼ sec. 7, T. 9 N., R. 7 W. reaches the sand at 238 feet above sea level. The sands in the V. Hall gas wells, sec. 8, although about 24 feet lower than in Klein No. 1, do not reach the level of the oil. In some cases, the gas sands are discolored and probably show the former presence of oil at a time when the salt water level was somewhat higher than at present. As the water level was lowered, the oil settled down dip by its own weight and drained the upper part of the sands, leaving them discolored perhaps, but with no free oil.

The gas accompanying brackish water in Klein No. 2 in the E. ½ NE. ¼ sec. 8, has been noted on a previous page. Its occurrence is exceptional. The water charged with gas was found in a sand at a depth of 450 feet, or 130 feet above sea level. Thus it occurs at a lower level than the bulk of the oil and gas in the field.

It is probable that a very small fold or flattening of the beds, with steeper dips above and below, occurs in the vicinity of Klein No. 2. A small amount of oil and gas on its way upward to the top of the water-bearing sand did not reach the crest of the dome, but was trapped in the minor fold below. The pressure developed was probably sufficient to cause most of the gas to be dissolved in the water, where it was held until the pressure was relieved by the drilling of Klein No. 2.

The oil has come into prominence only recently. V. Hall No. 1 in the NW. 1/4 SW. 1/4 sec. 8 and McClure Nos. 1 and 3 in the SW. 1/4 NE. 1/4 sec. 8 are the only wells so placed that they penetrate the zone of free oil. These wells are located down dip from the top of the dome, and all three reach oil at the same elevation above sea level. Up to the present time, no commercial amount of oil has been found in the Carlinville dome at a higher altitude than 184 feet above sea level. The lower limit of the oil sands and the areas regarded as most favorable for prospecting will be discussed under a later heading.

Since salt water immediately underlies the oil, any information regarding its position is of utmost importance. Somewhat unusual conditions exist in the Carlinville dome. The oil sand has been found dry in the McClure wells at 162 feet above sea level. In V. Hall N. 5—600 feet west of McClure No. 1—troublesome salt water was reached at an elevation of 210 feet. V. Hall No. 4 shows salt water in the upper part of the dome.

It is almost certain that these higher bodies of salt water are not part of the general zone of saturation. It has been mentioned above that the sands are more or less irregular or lenticular. Since this is true, it is possible that certain lenses surrounded by impervious beds are capable of holding salt water at a higher level than would be possible if the sands were all of the same horizon and continuous.

Another explanation for the higher salt water in the V. Hall wells, attributes the "drowning" of the sands to the fact that no effort was made to shut out the water in the old well of 1867, which was located near the east quarter corner of section 7. So far as can be learned, this well was drilled deep enough to reach salt water, and upon abandonment no attempt was made to protect the adjacent sands from "drowning." It is probable that for many years the salt water has percolated slowly down dip from the well and has affected a considerable territory in section 8.

The level of salt water in the neighborhood of the Carlinville dome is difficult to determine accurately from the available data. The log of Haacke No. 1 in the SW. 1/4 NW. 1/4 sec. 17, shows salt water at a depth of 421 feet or 156 feet above sea level. E. W. Denby No. 1 in the SE. cor. NE. 1/4 sec. 7 reaches salt water at 427 feet, or 145 feet above sea level. F. Hall No. 1 in the NW. 1/4 SW. 1/4 sec. 5, T. 9 N., R. 7 W. taps the same horizon at a depth of 505 feet, or 150 feet above the sea.

On account of the uncertain thickness of the sands, great care must be exercised while drilling, in order not to tap the salt water after reaching "pay." In V. Hall. No. 5, in the SE. 1/4 NW. 1/4 sec. 8, although the sand was penetrated only 9 feet, salt water was present on the day following the completion of the well and has continued to be very troublesome. McClure Nos. 1 and 3 end in sand only a few feet above the general level of salt water in the district, and any attempt at "shooting" would probably admit bottom water.

Probable Extension of Field

It is unwise and, in fact, impossible to predict with certainty, the presence of oil and gas in any given locality. The Carlinville field presents difficulties because of the marked irregularity in the thickness and character of the sand. However, after a careful study of all available data, it is possible to point out the areas in which the geological structure is most favorable for the accumulation of these materials.

It seems reasonable to expect oil at about the same level on all sides of the irregular dome at distances from the central gas area, varying inversely as the dip of the oil sands (see map, Plate VIII). Because of the steep dips on the west side, the productive area will probably be narrower than on the east and northeast where the strata dip more gently. Whether or not oil will be found in commercial quantities is a question which can be settled only by the drill. The crest of the Carlinville dome has been tested by Klein No. 1 in the E. 1/2 SE. 1/4 sec. 7 and the V. Hall gas wells in the western part of sec. 8. Only V. Hall No. 1 and McClure Nos. 1 and 3 tap the body of oil which is believed to extend around the irregular elongated dome. The salt water wells that have been drilled north, west, and south of the productive area, together with the apparent rapid dip of the sands away from the dome, seem to signify that in the eastern part of sec. 7 and in the western part of sec. 8, the productive zone will be narrow, and the location of successful oil wells most difficult.

On the north side of the dome the E. 1/2 NW. 1/4 sec. 8 seems to warrant testing. The V. Hall farm should be prospected by a well located on the south side of Macoupin Creek near the east line of the property. The McClure farm, upon which considerable drilling is being done, lies along the main axis of the elongated dome, and contains the best oil wells developed in the field up to the present time.

While the attitude of the sands northeast of the productive area is uncertain, it is believed that the dip in this direction is more gentle than that of the beds west of the dome. If this is true the sands may contain oil for a considerable distance northeast of the present area before reaching the level of salt-water saturation. At any rate, further prospecting should be done in a general northeast direction from McClure Nos. 1 and 3.

It is hoped that in the near future the State Geological Survey will be able to undertake further detailed investigations in Macoupin County, in an effort to locate other districts in which the structure is favorable for the accumulation of oil and gas.

The Survey is always glad to cooperate with oil men and to give them the benefit of any studies which may be made. To this end, it is necessary that detailed logs be kept by the driller with careful identification of the materials passed through with each screw. Any detailed information furnished by the operator will be held confidential if so desired.

THE GEOLOGY AND MINERAL RESOURCES OF THE SPRINGFIELD QUADRANGLE

By T. E. Savage

(IN COOPERATION WITH U. S. GEOLOGICAL SURVEY)

OUTLINE

PAGE

ILLUSTRATIONS

TABLES

THE GEOLOGY AND MINERAL RESOURCES OF THE SPRINGFIELD QUADRANGLE

INTRODUCTION

Location and Importance of the Area

The Springfield quadrangle embraces a rectangular area about 226 square miles in extent in the vicinity of Springfield, Illinois (Plate XI). It is situated a short distance west of the center of the State, its western border lying about 95 miles east of Mississippi River. The area is included between meridians 89° 30' and 89° 45' longitude, and between parallels 39° 45' and 40° 0' latitude. It has a length of about 17 miles and a width of about 13 miles. The greater portion of the quadrangle lies within the borders of Sangamon County, north of which there are included about 7 square miles in the southwest part of Logan County and 25 square miles in the southeast corner of Menard.

The topographic mapping and geological work in the area has been done by the Illinois Geological Survey in cooperation with the United States Geological Survey. The name Springfield was applied to the quadrangle from the city of Springfield, the county seat of Sangamon County and capital city of Illinois, located near the center of the south half of the area. Riverton, Athens, Cantrall, and Spaulding are other towns within the quadrangle.

The most important mineral resources of the Springfield region are coal and clay or shale. Thirty coal mines are operated within the area, the combined output of which for the year 1910 exceeded 4,000,000 tons. All the coal mined within the quadrangle is taken from coal bed No. 5, the Springfield coal, although a few miles south of the area, at Auburn, Divernon, and Pawnee, coal No. 6 is the seam worked. The entire area is underlain by the coal No. 5 within easy working distance below the surface. The quality of the coal is good and the mining conditions are favorable.

Extremely good distributing facilities are afforded by the presence of the following railroads within the quadrangle: Chicago, Peoria and St. Louis; the Chicago and Alton; the Illinois Central; the Wabash; the Cincinnati, Hamilton, and Dayton; and the Baltimore and Ohio Southwestern. Besides these railroads there are interurban lines connecting Springfield with Decatur to the east, Peoria and Bloomington to the north, and St. Louis to the south.

The wealth of coal deposits and the excellent markets afforded by the numerous railroads have given to the city of Springfield the commanding place it holds today, and insure its constantly increasing importance as an industrial center.

ACKNOWLEDGMENTS

Brief reports on the geology of Menard and Logan counties were published by Bannister [1] in 1870. Three years later Worthen [2] published a general report on the geology of Sangamon County. Considerable information concerning the coal mines, mining equipment, and statistics on coal production in this area has been given in the successive annual coal reports of the Illinois Bureau of Labor Statistics. In the study of the glacial geology of Illinois, Leverett[3] gave a short description of the drainage, depth of water wells, and thickness of the drift in Sangamon County. The same writer[4] also described the Sangamon soil and weathered zone that lies between the Illinoian till and the Iowan loess in this region.

The present writer[5] has discussed the water resources of the Springfield quadrangle and has also described the clay seams or "horsebacks"[6] in coal No. 5 in this region, and suggested an explanation of their mode of origin. Much of our knowledge of coal No. 5 (Springfield coal) and of the overlying strata which lie so deep that they do not outcrop in natural exposures within the area and the details of structure of the strata were made possible only through the cooperation of the coal operators, who generously furnished to the Survey copies of the private records of their mine shafts and test borings. Acknowledgment of these favors is here gladly made.

TOPOGRAPHY

GENERAL STATEMENT

The moderate surface relief of the region is favorable for transportation, the construction of railroads, and the development of mining in every part of the quadrangle (see Plate XI). The topographic features present in the area are of four distinct types: (1) isolated morainic mounds or hills, present only near the northeast corner; (2) upland prairies, comprising the level, unforested, interstream areas which include more than one-half the entire quadrangle; (3) erosion belts, imme-

[1]Bannister, H. M: Geol. Survey of Ill. vol. 4, pp. 163-189, 1870.
[2]Worthen, A. H: Geol. Survey of Ill. vol. 5, pp. 306-319, 1873.
[3]Leverett, Frank, Illinois glacial lobe: U. S. Geol. Survey Mon. 38, pp. 724-725, 1899.
[4]Idem, pp. 125-126. Also Proc. Iowa Acad. of Sci. vol. 5, pp. 71-80, 1897.
[5]Savage, T. E.: Ill. State Geol. Survey Bull. 4, pp. 235-246, 1907.
[6]Savage, T. E.: Economic Geology, vol. 5, No. 2, pp. 178-187, Mar., 1910.

diately bordering the larger streams; (4) flood plain areas of variable width, the more important of which border Sangamon River, South Fork, Sugar Creek, and Spring Creek.

The details of the topography of the region and the altitude of the surface are shown by contour lines on the topographic map[1] of the area. Each of these lines passes through points of equal elevation above sea level. The successive contour lines are separated on the ground by a vertical interval of ten feet. The location of the streams, township and section lines, public roads, railroads, towns, and houses are also represented on this map.

Surface Relief

The range of relief within the quadrangle is about 160 feet. The altitude over nearly two-thirds of the area is included between the elevations 580 and 620 feet above sea level. The highest point, about 645 feet, is the top of German Hill near the northeast corner. The lowest point, about 485 feet, is on the west side where Sangamon River leaves the area. The surface is that of a comparatively level, drift-formed plain, lying at an elevation of about 600 to 620 feet above the sea, into which the larger streams have cut their valleys to a depth of 75 to 150 feet below the uplands.

Drainage

Sangamon River, which flows in a general westerly direction across the middle part of the quadrangle, controls the drainage of the entire area. It has an average width of about 200 feet, and a depth varying between seasons of drought and flood from 1 to 20 feet in the shallower portions, and 10 to 30 feet in the deeper places. The discharge ranges from 200 to 10,000 cubic feet per second.

The larger tributary streams of the Sangamon within the area are, South Fork, Sugar Creek, and Spring Creek on the south and Wolf, Fancy, and Cantrall creeks on the north.

GENERAL GEOLOGY

Commercial Aspects

The economic value of a study of the geology of a region consists in the determination of the character, conditions of occurrence, availability, and distribution of the important deposits that occur in the area.

In the investigation of coal resources it is important to know the number and extent of the beds; the thickness and depth below the surface of each of these at various points; the defects of the beds; and the quality

[1]Copies of this map can be obtained from the Director, State Geological Survey, Urbana, Ill.; or the Director, U. S. Geological Survey, Washington, D. C., for 10 cents each.

of the coals. A knowledge of the structure of the coals and associated strata including the dips and deformations of the beds, and the character of the layers that underlie and overlie the coals are also highly important factors in determining the location of mine shafts and in forming an intelligent estimate of the expense of mining. In the study of clay beds, a knowledge of the character, quality, and extent of the material; the amount and character of the overburden; the accessibility of fuel supplies; and the facilities for marketing the wares is very important.

Information of the character mentioned above can be obtained only by a careful study of the rocks of the region where the valuable deposits occur and with which they are associated.

Stratigraphy

KINDS OF ROCKS IN THE AREA

The rocks of the Springfield quadrangle consist of: (1) surficial materials, composed of unconsolidated beds of glacial till or drift, loess, sand, and alluvium which have been derived from the breaking down of pre-existing rocks; and (2) sedimentary rocks, which underlie the surficial materials and consist of more or less consolidated beds of sandstone, shale, limestone, and seams of coal, arranged in nearly horizontal layers.

SURFICIAL MATERIALS

The surficial materials in this area comprise glacial, aeolian, and fluvial deposits, which cover the sedimentary rocks to an average depth of about 35 feet. They are thinnest over the areas that formed the highlands in pre-glacial time and are thickest above the valleys of the early Pleistocene streams. Sangamon River follows such an old valley along its northward course near the west side of the quadrangle. Over this valley a well in the NW. 1/4 sec. 23, T. 18 N., R. 6 W. was put down 170 feet without reaching the bottom of the surficial materials. The altitude of the bottom of this drilling was 125 feet lower than the surface of the consolidated rocks two miles further east.

INDURATED ROCKS

GENERAL DESCRIPTION

The hard rocks of this region have been studied in natural exposures through a thickness of 225 feet. By means of test borings for coal and oil they have been explored to a depth of 1,500 feet. Columnar sections of the logs of representative coal shafts and test borings are given in Plate XII. These show in detail the character and sequence of the strata that underlie the surface materials as far as they have been explored in this region. All the information concerning the rocks underlying the Pennsylvanian strata in this area is obtained from a drilling near Springfield, a log of which is shown in section 1, Plate XII. The succession and geological position of these rocks are also shown in the following generalized section.

Generalized section of hard rocks known in the Springfield quadrangle

	Thickness *Feet*
Carboniferous system—	
Pennsylvanian series—	
McLeansboro formation—including all of the Pennsylvanian strata above the top of coal No. 6, and composed of shales, sandstones, some impure limestones, and thin coals	46–225
Carbondale formation—embracing all of the strata between the base of coal No. 2 and the top of coal No. 6; and consisting of shales, sandstones, limestone, and productive coal beds; about..	243
Pottsville formation—comprising the strata between the bottom of the Pennsylvanian and the base of coal No. 2, and composed mostly of sandstones in the lower and shales in the upper part, with interbedded thin coals; about	278
Mississippian series—	
Salem and St. Louis formations—predominantly limestones with some shales; about	215
Keokuk and Warsaw formations—dominantly shales with some limestones; about	164
Burlington formation—cherty limestones and chert; about	106
Kinderhook formation—greenish to bluish-gray shale, limestone and red shaly limestone; about	155
Devonian system—	
Upper Devonian series—dark shale with spores of *Sporangites* abundant; about	133
Middle Devonian series—(Hamilton of Iowa or Northwest province) gray limestone; to bottom of boring	28+

POTTSVILLE FORMATION

Pottsville strata comprising the base of the Pennsylvanian series have been explored in three deep borings. They consist of coarse, gray sandstone and some conglomerate in the lower part, and shales or sandy shales predominating in the middle and upper portions. A thin coal bed lies about 140 feet from the base, and a somewhat thicker coal about 100 feet above the former and 33 feet below the bottom of coal No. 2.

CARBONDALE FORMATION

It has seemed desirable by the Survey to use the name Carbondale as a substitute for, and to make it embrace all of the strata that were included in, both the Petersburg and the La Salle formations as described in a previous report.[1] This is the important coal-bearing formation in

[1]DeWolf, F. W., Introduction to studies of Illinois coal: Ill. State Geol. Survey Bull. 16, p. 180, 1910.

the State. Its basal member, coal No. 2, consists usually of two thin beds separated by about 4 feet of dark shale. Above this coal is a shale which is followed by sandstone, and that succeeded by dark-colored shale up to an 18-inch coal bed, about 80 feet above coal No. 2. Between this coal and the next higher coal bed is an interval of about 55 feet, occupied almost exclusively by dark shale. Above this coal gray or blue to black shales extend to coal No. 5 which lies about 54 feet above the next lower coal.

Coal No. 5 (Springfield coal) is the important coal seam in this region and has an average thickness of about 6 feet. It contains numer-

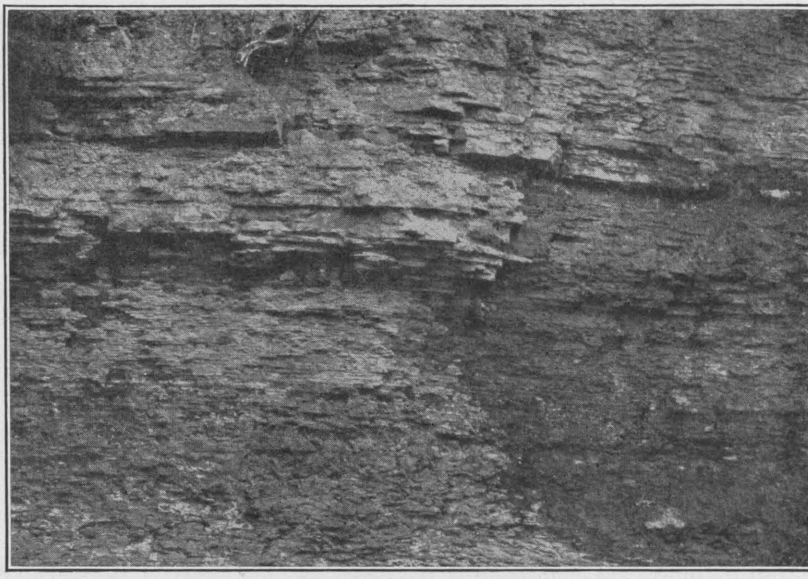


FIG. 1. Shale bed a short distance above coal No. 7, exposed in the south bank of Spring Creek, NE. ¼ sec. 25, T. 16 N., R. 6 W.

ous characteristic clay seams or "horsebacks" which extend down into it, or through it, in a more or less vertical direction. The roof of this coal consists of 3 to 5 feet of black, laminated, fissile shale bearing numerous shells of *Orbiculoidea missouriensis* and other fossils, and containing in the lower part numerous rounded nodules ("niggerheads") of calcareous pyritic shale. A limestone cap rock, generally about 12 inches thick, overlies the black shale, and is followed by 1 to 4 feet of light-colored shale. Coal No. 6 lies about 50 feet above coal No. 5, and, with the exception of the No. 5 cap rock, the strata lying between these coals are mostly shale.

Within the quadrangle coal No. 6 is only 2 to 14 inches thick, but it becomes thicker and has been mined at Mechanicsburg to the east and at Chatham to the south, only a short distance from the borders of this area.

McLEANSBORO FORMATION

The roof shale of coal No. 6, the basal member of the McLeansboro formation, is 3 to 5 feet thick. It is followed by about 6 feet of limestone which contains *Fusulina ventricosa* as the characteristic fossil. A thin coal (No. 7) 3 or 4 inches thick, occurs about 45 feet above the No. 6 bed. Between these coals are several feet of red, mottled shales which are exposed at Ralls Ford on Sangamon River, and constitute a very charac-

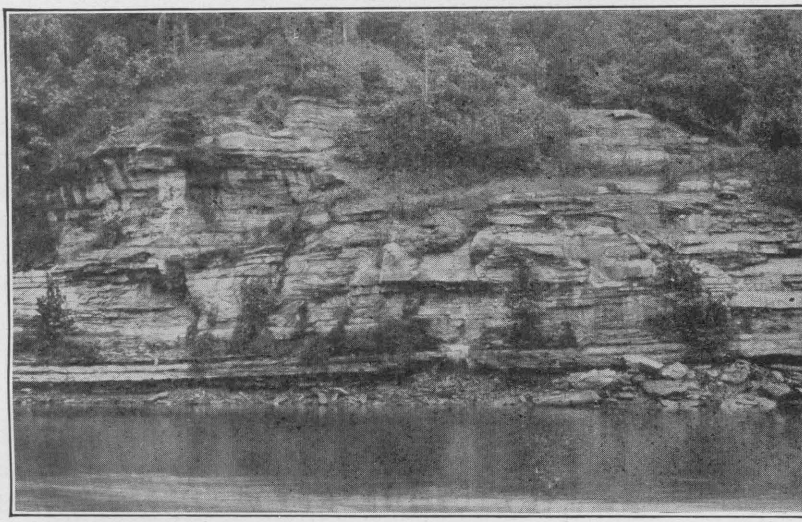


FIG. 2. View of sandstone below coal No. 8, exposed in the north bank of Sangamon river at Carpenter's bridge, NW. 1/4 sec. 1, T. 16 N., R. 5 W.

teristic and easily recognized horizon throughout this region. The shale may, for convenience, be called the Ralls Ford shale member. Above coal No. 7 there follows a bed of bluish-gray shale with occasional sandy layers about 45 feet thick, exposed in the south bank of Spring Creek in the NE. 1/4 sec. 25, T. 16 S., R. 6 W., and shown in figure 1.

Over a very limited area near the extreme northwest corner of the quadrangle there outcrops along Indian Creek about 6 feet of hard, gray, partly brecciated limestone which is better exposed in the banks of Rock Creek a few miles west of Athens. This limestone is thought to correspond with the Lonsdale quarry limestone in the Peoria quadrangle. Over the greater portion of the Springfield area this limestone is wanting, but its place appears to be at the top of the shale bed above coal No. 7.

Above this shale are 30 or more feet of sandstone exposed in the north bank of Sangamon River at Carpenters bridge, NW. 1/4 sec. 1, T. 16 N., R. 5 W. (see figure 2). A few feet of shale separates this sandstone from coal No. 8 and associated beds.

Coal No. 8, the under clay below, and the roof shale and cap rock above, comprise a succession of strata that are easily recognized in the logs of mine shafts and test borings in the central and eastern portions of the area. They outcrop in the west bank of Sugar Creek, sec. 13, T. 15 N., R. 5 W.; in the south bank of Sangamon River, sec. 6, T. 16 N. R. 4 W.; and in the east bank of Fancy Creek, sec. 13, T. 17 N., R. 4 W.

Above the limestone overlying coal No. 8 is 40 or 50 feet of shale exposed in the shale pit of the Springfield Paving Brick Co. near Springfield as shown in figure 4. This is followed by about 35 feet of sandstone which outcrops along Sangamon River near the middle of sec. 4, T. 15 N., R. 4 W. and in the south half of sec. 27, T. 16 N., R. 4 W.

Belonging a few feet above this sandstone is the Crow's Mill limestone, exposed in the old quarry near Crow's Mill along Sugar Creek about 3 miles south of the quadrangle. This is a hard limestone, bearing large shells of *Productus, Spirifer,* and *Composita.* It occurs in heavy layers, large masses of which, more or less shifted by the ice sheets of the glacial period, are present in the area under discussion.

Structure

METHOD OF REPRESENTING STRUCTURE

The structure of rocks may be represented either by cross-sections or by contour lines. Cross-sections are best for a region in which the rocks are much faulted or very strongly folded; but where the folds are low and there is little or no faulting, the use of contour lines shows the structure more clearly. In this region the layers of rock are nearly horizontal but have a general eastward dip of a few feet per mile, which is interrupted by low folds and local small irregularities.

On the accompanying map (Plate XI) the structure of this region is represented by contour lines, the altitude of coal No. 5 having been used as the base. The altitude of this coal was determined in many places from the logs of mine shafts and coal test borings, and by computations from the altitude of outcrops of coal No. 8 or of some other easily recognized stratum, the average distance between which and coal No. 5 is known.

The elevation of coal No. 5 in the various borings and mine shafts was determined as follows: The altitude of the top of the several test holes and mine shafts was generally found by hand leveling from the nearest bench mark. Where no bench mark was found near the boring or shaft, the surface elevation was determined by aneroid barometer reading which was checked with the nearest bench mark. From the surface altitude of each hole, was subtracted the depth to the bottom of coal No. 5 in the respective places as given in the logs.

In estimating the altitude of coal No. 5 from outcrops of coal No. 8, the elevation of the No. 8 bed at the several places was determined in the same manner as for the surface elevation of the shafts and test borings. From these figures was subtracted the average distance between coal No. 8 and coal No. 5.

The greater part of the surface data on which the map is based is shown in Table 35.

TABLE 35.—*Locations and altitudes of observation points*

Location			Map No.	Feet above sea level of bottom of coal No. 5	Method of determination of elevation[a]
T. N.	R. W.	Sec.			
18	5	36	1	407	L
17	4	17	1	325	L
17	4	31	1	336	C
17	4	35	1	311	L
17	5	8	1	390	L
17	5	9	1	378	C
17	5	9	2	381	C
17	5	27	1	373	L
17	5	36	1	346	L
17	6	1	1	394	L
16	4	4	1	330	L
16	4	5	1	338	C
16	4	8	1	338	L
16	4	9	1	320	L
16	4	10	1	312	L
16	5	12	1	330	L
16	5	13	1	350	L
16	5	13	2	348	L
16	5	14	1	332	L
16	5	14	2	335	L
16	5	19	1	365	L
16	5	20	1	379	E
16	5	21	1	360	L
16	5	23	1	335	L
16	5	24	1	336	L
16	5	24	2	340	L
16	5	29	1	380	L
16	5	31	1	397	L
16	5	32	1	385	L
16	5	32	2	386	C
16	5	32	3	391	C
16	5	35	1	372	L
15	4	5	1	335	L
15	5	1	1	336	L
15	5	3	1	352	L
15	5	3	2	353	L
15	5	5	1	365	E
15	5	9	1	351	L
15	5	12	1	346	C
15	5	13	1	344	C

[a]L, Hand level; E, Estimated from topographic map; C, Calculated from average distance from some known stratum, the altitude of which was determined by barometer.

Between the locations at which the elevations of coal No. 5 were determined the dip is assumed to be uniform. Hence, on the structure map a line connecting all of the known points at which coal No. 5 occurs at an altitude of 400 feet above sea level constitutes the 400-foot contour line. In the same manner all of the points at which this coal was found to lie 375 feet above the sea are connected by the 375-foot contour line, and so on. A dip or 25 feet is indicated between any two adjacent contour lines.

ACCURACY OF STRUCTURE CONTOURS

The accuracy of the structure contours on the map depends upon the accuracy of the surface elevations obtained, the variation from the average distance between coal No. 5 and coal No. 8 as used in the calculations, and upon the number and distribution of the places at which the altitude of coal No. 5 was determined.

In this area bench marks are numerous and consequently the hand level and barometer determinations involved only short horizontal distances and small probabilities of error. The distance between coal No. 5 and coal No. 8 in this region does not vary more than a few feet from the average, so that the error arising from this is very small. The number of points at which the altitude of coal No. 5 was determined is not so great as might be desired, but they are fairly well distributed, which tends to reduce the inaccuracies arising from this factor. When all the possibilities of error are allowed, it is thought that the structure lines are correct within a contour interval, and that the general altitude or "lay" of coal No. 5, and thus the general structure of the Pennsylvanian strata in this area is essentially as shown on the map. Minor irregularities less than 25 feet in vertical height may not be represented.

USE OF THE STRUCTURE MAP

The structure map is of practical use in connection with the topographic map of the area as a means of determining the approximate depth of coal No. 5 below the surface at any place. From the contour lines on the structure map the altitude above sea level of the bottom of coal No. 5 at any place can be approximately found; from the topographic map the altitude of the surface at the same place in the quadrangle can be readily determined. The difference between this surface altitude and the elevation of coal No. 5 will represent the approximate depth below the surface of coal No. 5 at the specified place. The structure map also shows the direction and amount of dip of the strata in the different parts of the area, a knowledge of which is most essential in all mining operations.

STRUCTURE OF THE SPRINGFIELD QUADRANGLE

In this area the highest altitude at which coal No. 5 is known to occur in mine shafts is 407 feet at the Wabash Coal Company's mine at Athens. The lowest known altitude, 311 feet, is in the shaft of the Barclay Coal Mining Company, near the east border of the area. Along a line from Athens to Riverton, in a direction nearly due southeast, the dip of coal No. 5 towards the southeast is somewhat uniform, as shown by the altitude of this coal in mine shafts at the following points: Athens, 407 feet; Cantrall, 390 feet; Andrew, 373 feet; Peabody, 346 feet; Riverton (mine No. 1), 320 feet. The distance between Athens and Riverton is about 12 1-3 miles. The difference in the altitude of this coal between the two places is 87 feet, the average dip of coal No. 5 towards the southeast being nearly 8 feet per mile. The eastward dip of the strata between Cantrall, where the bottom of coal No. 5 is reached at 390 feet altitude, and Selbytown, where the same bed lies at an altitude of 325 feet, is 65 feet. The distance between these places is 6 miles, and the average eastward dip for this distance is about 11 feet per mile.

The calculated altitude of coal No. 5 at Ralls Ford is 424 feet; the altitude of this coal in mine No. 2 at Riverton, 11 miles due east of Ralls Ford, is 318 feet. This difference would indicate an eastward dip of 106 feet in a distance of 11 miles or an average slope of nearly 10 feet per mile.

The general slope of the strata from north to south is much less steep than that from west to east. From Cantrall, where the altitude of coal No. 5 is 390 feet, to the shaft of mine "A" of the Citizens Coal Mining Company, where its altitude is 386 feet, is a distance of 10 miles in a direction nearly due south. This would indicate a southward dip of only 4 feet in 10 miles or an average of only 5 inches to the mile. South of mine "A" of the Citizens Coal Mining Company the dip increases somewhat. In a boring 1½ miles south of this shaft the base of coal No. 5 was found at an altitude of 364 feet, which indicates a dip of about 15 feet per mile between these places. The rate of dip at different points varies considerably from the above figures. In some places coal No. 5 lies almost level over a few square miles, whereas locally the dip may exceed 20 feet per mile. It will be seen from the structure map that in the northern part of the area the dip of the strata is quite uniform, but in the southern part a marked deformation is apparent.

In Table 36 the general eastward dip in both the coal beds is apparent from the series of altitudes in each half township width across the quadrangle in an east-west direction, and in the general average elevations by half townships. The slight southward inclination of both coal beds along the middle part of the quadrangle is brought out in the second and third columns. The local variations in the altitudes in the east and west portions of the quadrangle, which disturb the general southward inclination of the strata appear from columns 1, 4, and 5. The total number of places at which the altitude of coal No. 5 is known is 40. The average altitude of the bottom of this coal bed for all of

TABLE 36.—*Average altitude of the bottom of coal No. 5 and coal No. 8 in each half township of the Springfield quadrangle*

		(1) R. 6 W. (E. ½)		(2) R. 5 W. (W. ½)		(3) R. 5 W. (E. ½)		(4) R. 4 W. (W. ½)		(5) R. 4 W. (E. ½)	
		Number of altitudes averaged	Average altitude in feet	Number of altitudes averaged	Average altitude in feet	Number of altitudes averaged	Average altitude in feet	Number of altitudes averaged	Average altitude in feet	Number of altitudes averaged	Average altitude in feet
Coal No. 5	T. 18 N.	1	407								
	T. 17 N.			4	385	2	360	2	331	1	311
	T. 16 N.	1	424	6	379	11	348	4	331	1	318
	T. 15 N.			2	358	5	346	1	335		
	Total average west-east....		416		377		351		332		314
Coal No. 8	T. 17. N.			2	562	1	560	2	517		
	T. 16 N.			2	553	4	549	2	528	1	515
	T. 15 N.			1	550	2	529				
	Total average west-east....				556		545		522		515

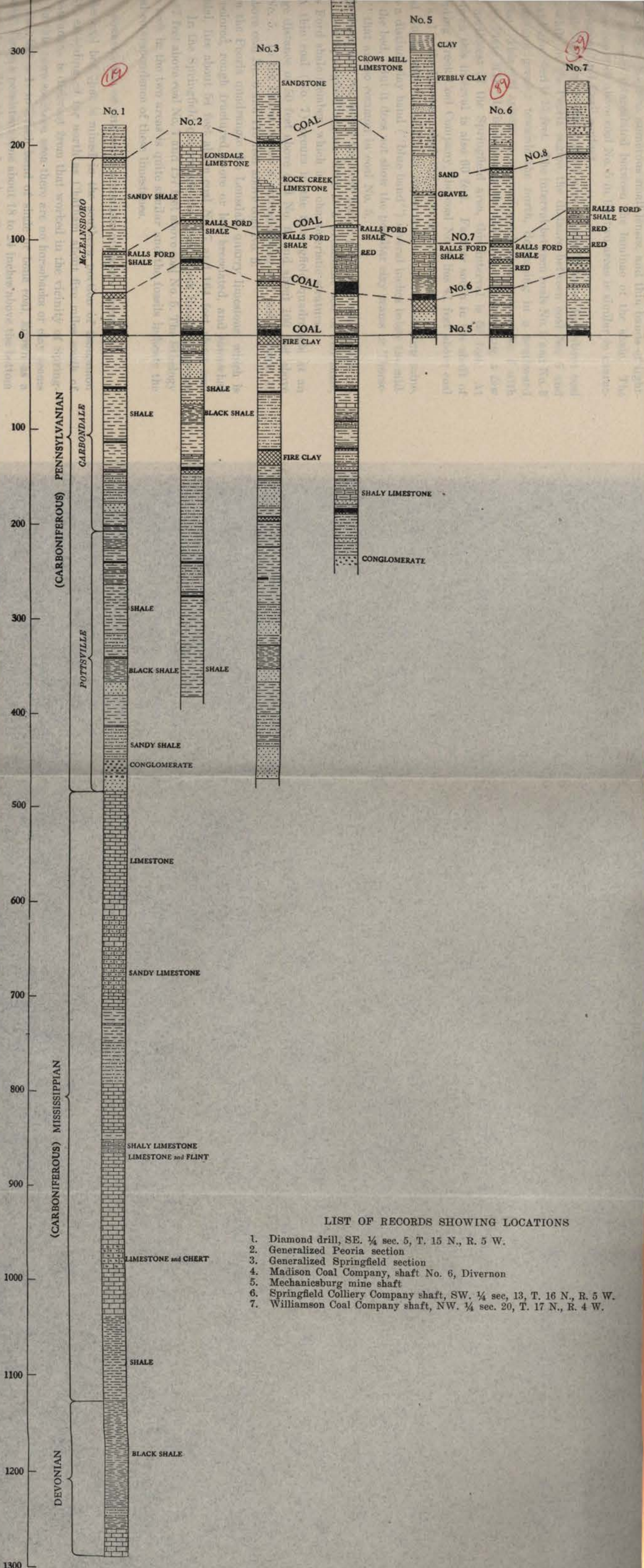
these places is 356 feet. The extreme difference in the altitudes of this coal bed within the quadrangle is 113 feet. The altitude of coal No. 8 has been determined at 16 places. This coal bed is separated from coal No. 5 by an average distance of 175 feet. At a place one mile east of Cantrall the altitude of coal No. 8 is 563 feet, whereas at Selbytown, 5½ miles farther east, the altitude of this bed is 514 feet. This would give to coal No. 8 an eastward slope of about 10 feet per mile. In a north and south direction the general altitude of coal No. 8 in Tps. 15, 16, and 17 N. Rs. 5 and 4 W., averaged for the east and west half of each township, may be seen by referring to Table 36. The figures indicate that the strongest inclination of coal No. 8 is towards the east; that it dips southward along the middle range of townships in the quadrangle, but that this general southward slope is disturbed in the eastern part of the area. The structure of coal No. 8 agrees for the most part with the general direction and degree of inclination of coal No. 5, and it also partakes to a large extent of the irregularities of dip displayed by that bed.

Correlations

CORRELATION OF THE SPRINGFIELD AND PEORIA SECTIONS

Coal No. 5 (Springfield) which is mined in both the Springfield and Peoria districts, presents in each area many characteristic "horsebacks" in the form of branching, clay-filled fissures. The abundance of these "horsebacks" in the coal bed, the absence of any persistent clay parting or "blue band" in the coal, the similarity of the roof shale and cap rock and of the general succession of the beds above the coal in the two areas make it practically certain that this coal represents an equivalent stratum in the two localities.

The resemblance in the succession of the Pennsylvanian strata above coal No. 5 in the two areas will appear from a study of the columnar sections 2 and 3 of Plate XII. Number 2 is a generalized section ot the Pennsylvania strata in the Peoria quadrangle, compiled from the report by Dr. Udden on that area. That part of number 3 above coal No. 5 is a generalized section of the Pennsylvanian beds in the Springfield quadrangle compiled from the natural exposures and from the logs of several mine shafts and borings in the area. The portion of number 3 below coal No. 5 is compiled from records of drillings made near Springfield and at Riverton. It will be seen from the detailed comparison of these columnar sections, that the succession of beds between coal No. 5 and the Lonsdale quarry limestone in the Peoria region corresponds closely with that of the strata in the Springfield area lying between coal No. 5 and the Rock Creek limestone. The shale above coal



LIST OF RECORDS SHOWING LOCATIONS

1. Diamond drill, SE. ¼ sec. 5, T. 15 N., R. 5 W.
2. Generalized Peoria section
3. Generalized Springfield section
4. Madison Coal Company, shaft No. 6, Divernon
5. Mechanicsburg mine shaft
6. Springfield Colliery Company shaft, SW. ¼ sec, 13, T. 16 N., R. 5 W.
7. Williamson Coal Company shaft, NW. ¼ sec. 20, T. 17 N., R. 4 W.

Stratigraphic sections from the Springfield quadrangle.

No. 5 in each area bears similar fossils, and is hard, black, and finely laminated, and contains numerous small lenses, and thin bands of light-colored material intercalated between the laminae of the shale. The limestone cap rock above coal No. 5 in the two areas is similar in character, thickness, and fossil content.

Coal No. 6 in the Springfield area occurs 50 to 60 feet above coal No. 5 while in the Peoria region the distance between coal No. 5 and the next higher bed is 75 feet. The interval between coals No. 5 and No. 6 is in general greater towards the north, decreasing in a southward direction. This will appear on comparing columnar sections No. 6 with No. 7 in Plate XII. It is shown by the fact that at Petersburg, a few miles northwest of the Springfield area, this interval is 60 feet. At Selbytown this interval is also 60 feet. Farther south in the shaft of the Spring Creek Coal Company, the coal No. 6 lies 41 feet above coal No. 5, and in the Divernon shaft the interval is 39 feet.

Coal No. 6, both in the Peoria region and the Mechanicsburg mine, shows a distinct clay band ("blue band") several inches below the middle of the bed. But it does not show the peculiar clay seams or "horsebacks" that are so common in coal No. 5.

Between coal No. 6 and the next higher persistent bed in both the Peoria and Springfield regions there is a prominent bed of red shale, Rall's Ford shale member, which is a characteristic stratum.

A thin coal (No. 7) occurs in the Springfield quadrangle at an average distance of 50 feet above coal No. 6, and about 100 feet above coal No. 5. In the Peoria region a corresponding coal bed is found 40 feet above coal No. 6 and 110 feet above coal No. 5.

In the Peoria quadrangle the Lonsdale quarry limestone, which is light colored, rough fractured, more or less brecciated, and somewhat crinoidal, lies about 54 feet above coal No. 7 and 164 feet above coal No. 5. In the Springfield quadrangle the Rock Creek limestone occurs about 57 feet above coal No. 7 and 157 feet above coal No. 5. The lithology of the rock in the two areas is quite similar and the fossils indicate the general correspondence of these limestones.

CORRELATION OF THE SPRINGFIELD AND DIVERNON SECTIONS

The coal bed that is mined in the southern portion of Sangamon County, extending as far north as Chatham about five miles south of the quadrangle, is different from that worked in the vicinity of Springfield. In this more southern area there are no horsebacks or clay seams in the coal, but a 1- to 3-inch band of shale or bone coal, known as a blue band, forms a persistent zone about 18 to 24 inches above the bottom of the coal bed. This blue-band coal at Chatham is between 5 and 6

No. 5 in each area bears similar fossils, and is hard, black, and finely laminated, and contains numerous small lenses, and thin bands of light-colored material intercalated between the laminae of the shale. The limestone cap rock above coal No. 5 in the two areas is similar in character, thickness, and fossil content.

Coal No. 6 in the Springfield area occurs 50 to 60 feet above coal No. 5 while in the Peoria region the distance between coal No. 5 and the next higher bed is 75 feet. The interval between coals No. 5 and No. 6 is in general greater towards the north, decreasing in a southward direction. This will appear on comparing columnar sections No. 6 with No. 7 in Plate XII. It is shown by the fact that at Petersburg, a few miles northwest of the Springfield area, this interval is 60 feet. At Selbytown this interval is also 60 feet. Farther south in the shaft of the Spring Creek Coal Company, the coal No. 6 lies 41 feet above coal No. 5, and in the Divernon shaft the interval is 39 feet.

Coal No. 6, both in the Peoria region and the Mechanicsburg mine, shows a distinct clay band (''blue band'') several inches below the middle of the bed. But it does not show the peculiar clay seams or ''horsebacks'' that are so common in coal No. 5.

Between coal No. 6 and the next higher persistent bed in both the Peoria and Springfield regions there is a prominent bed of red shale, Rall's Ford shale member, which is a characteristic stratum.

A thin coal (No. 7) occurs in the Springfield quadrangle at an average distance of 50 feet above coal No. 6, and about 100 feet above coal No. 5. In the Peoria region a corresponding coal bed is found 40 feet above coal No. 6 and 110 feet above coal No. 5.

In the Peoria quadrangle the Lonsdale quarry limestone, which is light colored, rough fractured, more or less brecciated, and somewhat crinoidal, lies about 54 feet above coal No. 7 and 164 feet above coal No. 5. In the Springfield quadrangle the Rock Creek limestone occurs about 57 feet above coal No. 7 and 157 feet above coal No. 5. The lithology of the rock in the two areas is quite similar and the fossils indicate the general correspondence of these limestones.

CORRELATION OF THE SPRINGFIELD AND DIVERNON SECTIONS

The coal bed that is mined in the southern portion of Sangamon County, extending as far north as Chatham about five miles south of the quadrangle, is different from that worked in the vicinity of Springfield. In this more southern area there are no horsebacks or clay seams in the coal, but a 1- to 3-inch band of shale or bone coal, known as a blue band, forms a persistent zone about 18 to 24 inches above the bottom of the coal bed. This blue-band coal at Chatham is between 5 and 6 feet thick, and at Divernon 10 miles farther south, the thickness is nearly 8 feet. Thirty-nine feet below this bed at Divernon is a coal 3 feet thick which is thought to represent coal No. 5.

In the Mechanicsburg shaft, shown in columnar section No. 5 Plate XII, a blue-band coal lies 27 feet above the "horseback" coal (No. 5) which is at present worked in that mine. The upper coal was 6 feet thick at the shaft, but thinned down to 2 inches at a distance of 800 feet to the north. In the Peoria quadrangle coal No. 6 carries a persistent "blue band" similar to that in coal No. 6 in the Mechanicsburg shaft, and similar to the coal mined at Divernon.

The section of the Divernon shaft is given as No. 4 on Plate XII. Assuming that the blue-band coal at Divernon is No. 6, and starting from coal No. 5 as a base, a comparison of the generalized Springfield columnar section No. 3, with columnar section No. 4, of the Divernon shaft, brings out some interesting facts.

The distance between coal No. 5 and coal No. 6 in the Springfield columnar section (No. 3) is 49 feet, whereas the corresponding interval in the Divernon section (No. 4) is about 39 feet. At a distance 100 feet above coal No. 5 in section No. 2 is another coal (No. 7), but in section No. 4, this second coal bed is 98 feet above coal No. 5. In section No. 3 coal No. 8 lies 195 feet above coal No. 5 while in section No. 4, the corresponding coal is found 207 feet above the No. 5 bed. In section No. 3 the Crow's Mill limestone lies about 274 feet above coal No. 5 and in section No. 4 a corresponding limestone occurs 267 feet above the No. 5 coal.

Below coal No. 5 the succession of coal beds shows a correspondence no less close. In columnar section No. 3, 2½ feet of coal lies 58½ feet below coal No. 5, whereas in columnar section No. 4 a bed 2 feet 2 inches thick is found 58 feet below coal No. 5. In section No. 3 another coal lies 120 feet below coal No. 5; in section No. 4 the corresponding distance is the same. In section No. 3 another coal band lies 151 feet below coal No. 5, and in section No. 4 the corresponding coal is 143 feet below coal No. 5. In section No. 3 a thin coal lies about 191 feet below coal No. 5, and in section No. 4 a thicker bed occurs 185 feet below coal No. 5.

In each of these sections a thin limestone occurs a short distance above coal No. 5, and a thicker bed of limestone is present in the interval between coals No. 6 and No. 7. The bed of red shale, Rall's Ford shale member, below the fire clay of coal No. 7 is also conspicuous in both sections. The heavy limestone bed, Crow's Mill limestone, 260 to 270 feet above coal No. 5 in each section marks an important horizon.

The evidence from the Mechanicsburg section, in which coals No. 5 and No. 6 are known to correspond respectively with coals No. 5 and No. 6 in the Springfield area, and the general correspondence in the entire succession of coals and limestones in the Springfield and Divernon sections, make practically sure the correlation of the blue-band coal at Divernon with coal No. 6, which is also a blue-band coal, at Mechanicsburg and in the Peoria region.

ECONOMIC GEOLOGY

The area included in the Springfield quadrangle is preeminently an agricultural region, and its productive soils constitute the greatest natural source of wealth. Of the mineral resources in the area the important deposits of coal and clay are of great economic value.

Coal Resources

The output of coal from the area included in the Springfield quadrangle for the year 1910 was about 4,127,998 tons. This was the combined output of 30 mines, all but two of which are commercial producers. From the columnar sections on Plate XII, it will be seen that coal occurs in this area at a number of levels. Of these beds, coal No. 5 is the only one that is at present being mined.

COALS BELOW NO. 5

A fairly persistent coal bed, about 2½ feet thick lies about 58 feet below coal No. 5. Another bed, which seems persistent, occurs about 120 feet below coal No. 5, and averages about 2 feet in thickness. Two other coal beds which are locally present, aggregating about 3 feet in thickness and separated by a few feet of shale, lie at a depth of about 191 feet below coal No. 5. In the Riverton section a 32-inch coal was reported 250 feet below the No. 5 bed, but in the Springfield boring the corresponding coal is much thinner. A few other thin bands occur locally in the Pennsylvanian strata below coal No. 5. At some future time one or more of these lower coals may be of economic importance, but until the No. 5 bed becomes practically exhausted, the deeper and thinner coals will not be exploited.

COAL NO. 5

CHARACTERISTICS OF COAL NO. 5

The coal known as No. 5 (Springfield) is the only bed at present worked in the quadrangle. Its thickness varies but little in the different mines, the range within the area being from 5½ to 6⅔ feet. It lies entirely below drainage, being found at depths from 150 to 273 feet below the surface. The depth to the coal at any one place depends both upon the altitude of the surface and the altitude of the coal at that place. Coal No. 5 is remarkably uniform and persistent, being found at every place where borings have been put down to its level, and it is also present in the State over an extensive territory to the west and south of the area.

CLAY SEAMS IN COAL NO. 5

One of the conspicuous features of coal No. 5 (Springfield) is the occurrence in it of numerous "horsebacks," as they are called by the miners. These are more or less irregular and branching fissures, filled with clay or shale, extending downward from the overlying beds into or through the coal. They range in width from 2 or 3 inches to 3 or 4 feet, the walls not being very nearly parallel, and are considerably and abruptly wider in the coal than in the overlying roof shale. (See fig. 3.)

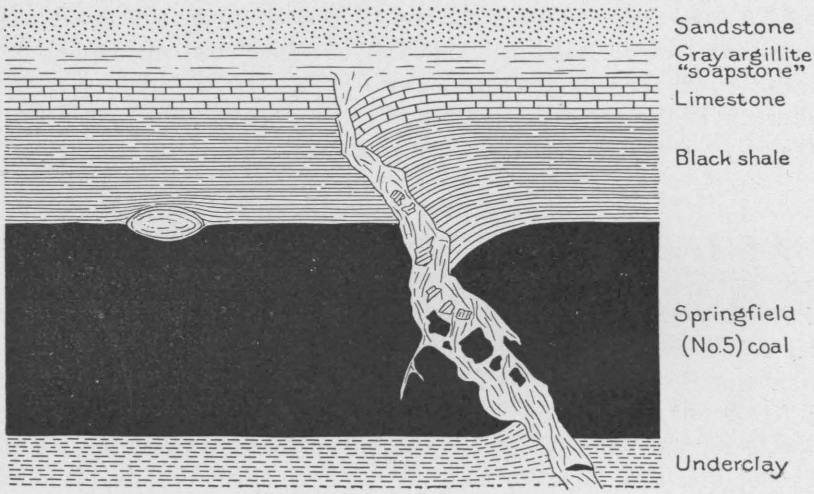


FIG. 3. Sketch of typical clay seam or "horseback" seen in mine No. 5, of Springfield Coal Mining Company, near Springfield.

The clay or shale filling the fissures is light gray and generally soft. Rarely it is hard enough to emit sparks when struck with a hammer, but as a rule it soon slakes down into an incoherent mass on exposure to the air. The clay in many fissures contains fragments of black shale derived from the roof of the coal, reaching down 29 inches below the top of the coal. A few fragments of limestone from the cap rock are also found in this clay below the top of the coal bed. In horsebacks that cut through the coal bed pieces of coal have been found as much as 9 inches below the bottom of the bed. No fragments of coal have been found higher than the top of the coal bed.

The fissures show no regularity of spacing or of direction. In some mines they are 40 to 60 feet apart; in others they are separated by 200 to 400 feet or more. They trend in various directions, no one direction predominating, even in the same mine. All are either vertical or steeply inclined, with irregular walls which gradually converge downward within the coal. They have a very slight vertical range. In the Mechanicsburg mine a coal bed, formerly worked, lies about 35 feet above coal No. 5, which is the coal now mined. Although coal No. 5 is cut by numerous horsebacks, none were encountered in the higher bed.

The walls of the fissures are slickensided but show no traces of weathering. Slickensided planes are also common in the clay filling the fissures. If the fissure is inclined, the uppermost laminæ of the coal adjacent to the fissure on the overhanging side are bent somewhat steeply downward, the distortion fading out laterally within a few feet from the fissure, and in a few places the lowermost laminæ of the coal on the other side of the fissure are bent upward but to a much less degree. If the fissure is vertical, or nearly vertical, the uppermost laminæ of the coal are bent downward on both sides of the fissure, but the more nearly vertical the fissure the less the amount of bending. In no fissure is there a true fault or a relative displacement of the middle part of the coal bed on the opposite sides of the fissure.

The material filling the fissures appears to have been derived chiefly from the gray shale overlying the cap rock of the coal bed and to have been forced downward into the coal through breaks in the cap rock, as is indicated by the downward bending of the edges of the cap rock and of the coal laminæ, by the occurrence of fragments of the cap rock below the top of the coal, and by the continuity of the material of the fissures with that of the bed of gray shale.

The coal appears to have yielded readily in a lateral direction, as shown by the greater width of the fissures in the coal bed than in the overlying and underlying strata. That the coal afforded accommodation to the strains causing the fissures is also indicated by the fact that many of the smaller fissures divide within the coal bed into branches which eventually die out in the coal.

ORIGIN OF CLAY SEAMS

The formation of the clay-filled fissures in the Springfield coal was probably determined in part by the character of the overlying strata and in part, possibly, by the character of the underclay, which is dry and does not creep readily. The fissures were formed after the coal bed had been compressed nearly to its present volume, as is shown by the fact that the clay seams are not so deformed as they would be if the coal had been greatly compressed after they were developed. In some places clay from the fissures has penetrated joints in the adjacent coal, indicating that joints had been developed in the coal prior to the formation of the clay seams. Campbell[1] suggests that the carbonization of the coal beyond the lignitic condition depends on the presence of joints and cleavage planes along which gases may escape. If so, the bed should have undergone considerable compression and contraction after the joints were formed before it became bituminous.

It is assumed that as the mass was slowly transformed into coal the contraction in its different parts was somewhat unequal, owing to its lack of homogeneity, and that the contraction continued long after the coal had been greatly consolidated. As long as the material possessed some degree of mobility the unequal shrinkage in the different parts of the bed was equalized by the movement of some of the mass toward points of least resistance. When the consolidation reached a certain stage such adjustment was no longer possible, so that continued unequal shrinkage of the mass produced unequal strains in the roof of the coal under its load of superposed rocks. Where the roof of the coal bed was a somewhat plastic shale the mobility of the particles of the shale permitted an adjustment of the inequalities of strain resulting from the unequal contraction of the coal bed, the adjustment being accomplished by the formation of rock rolls such as are common at the top of the Herrin coal (No. 6) in the Carterville-Zeigler region of southern Illinois. The roof shale in the vicinity of the rolls is cut by slickensided zones for several feet from the center of the roll, indicating a considerable lateral movement in the shale during the adjustment necessitated by the strains. The roof of the Springfield coal, however, is a hard, brittle shale without the mobility requisite for such adjustment. If the limestone cap rock had been very thick it might have withstood, without fracture, the strain due to unequal contraction in the underlying coal, but its average thickness is only 12 or 14 inches. The roof shale and the cap rock were together not strong enough to withstand the unequal strains to which they were subjected and broke under the pressure, at places marked by fissures.

Immediately above the cap rock is a bed of rather soft gray shale, the material of which was squeezed downward through the fissures into the coal until the inequalities of pressure were adjusted. The adjustment was limited to a narrow zone below the fractures in the roof shale

[1]Campbell, M. R., Econ. Geology, vol. 1, No. 1, p. 30, 1905.

and cap rock, and its effects are of slight horizontal extent but penetrate to considerable depths.

CONCRETIONS ABOVE COAL NO. 5

Rounded concretions of calcareous, pyritic shale, called pyrite balls or "niggerheads" and varying in size from one inch to four feet or more in diameter, are in places numerous along the contact zone of the black shale with the top of the coal. These concretions have been compressed less than either the overlying black shale or the underlying coal, and hence the laminæ of the black shale arch upward over the "niggerheads," and those of the upper part of the coal bend downward beneath them. The continued contraction of the coal seam, after the partial consolidation of the coal and of the overlying black shale, permitted a sufficient amount of movement to take place around and above the "niggerheads" to give their surface a slickensided appearance, and to cause them to fall readily from their matrix after the underlying coal has been removed.

COAL NO. 6

Coal No. 6 (Belleville or Herrin coal) is known only from the records of mine shafts and test borings, and as far as known is too thin to be profitably worked within this area. This bed was formerly mined at Mechanicsburg some distance east of Springfield and it is mined extensively 20 miles south. The coal where first penetrated by the Mechanicsburg shaft was about 6 feet in thickness, but it thinned rapidly northward, and was abandoned when coal No. 5 was discovered below it. In two of the shaft sections it was reported absent, but in these the horizon was marked by a black shale underlain by fire clay. This coal lies at an average distance of 49 feet above coal No. 5, the distance increasing in general toward the north.

In this quadrangle coal No. 6 varies in thickness between 2 and 14 inches, the average being 4½ inches. The thickness increases rapidly in a southerly direction. Near Waverly it is 3½ feet thick. At Chatham the thickness is between 5 and 6 feet, and at Divernon it is nearly 8 feet thick. This coal is mined extensively in the southern portion of Sangamon County, and farther south in the vicinity of Belleville, Duquoin, Carterville, and Herrin.

COAL NO. 7

Coal No. 7 is not thick enough to be of economic importance, measuring generally only 2 or 3 inches. In three of the shaft records the horizon is known only by the associated fire clay and black shale strata, the coal itself not being present. The position of this coal is 50 feet above coal No. 6, and about 100 feet above coal No. 5.

COAL NO. 8

The thickness of coal No. 8 varies from 18 to 31 inches. The bed lies above drainage over the whole of the area except in a belt about 3 miles wide along the east border, and it has been eroded away from a strip of about equal width along the west side of the quadrangle. For several years before the deeper and thicker bed, No. 5, was discovered, this was the only coal worked in the Springfield region. The mining was done by drifts run into the hillsides at points where the bed outcropped above the level of the streams. Traces of such workings may be seen along a branch in W. ½ sec. 32, T. 16 N., R. 5 W; along the west bank of Sugar Creek in sec. 12, T. 15 N., R. 5 W; and they are numerous along the south bank of Sangamon River in secs. 5 and 6 T, 16 N., R. 4 W. The greatest measured thickness of this coal was at the Sangamon River localities where it reached 31 inches. Coal No. 8 lies at an average distance of about 77 feet above coal No. 7, and about 175 feet above coal No. 5.

No swamp conditions or soil beds seem to have been developed in the interval between coals No. 5 and No. 6. Between coal beds No. 6 and No. 7 there is generally reported one, and in some instances two, layers of black shale with underclays. In a few places there is a thin bed of coal at one of these levels. Between coals No. 7 and No. 8 there is less frequently reported a clay-shale succession with a rare occurrence of a thin coal bed.

Interesting tabulation of the facts regarding the several coals is presented in Table 37.

A comparison of the thicknesses of the coal beds from No. 5 to No. 8, inclusive, and of the distances separating them in various mine shafts and borings is given in tabular form below.

TABLE 37.—*Thicknesses of the several coal beds and the distance between them in mine shafts and borings*

Name of mine	Thickness of coal No. 5	Distance between coals No. 5 and No. 6	Thickness of coal No. 6	Distance between coals No. 6 and No. 7	Thickness of coal No. 7	Distance between coals No. 7 and No. 8	Thickness of coal No. 8	Total distance from top of coal No. 5 to base of coal No. 8
	Inches	*Feet*	*Inches*	*Feet*	*Inches*	*Feet*	*Inches*	*Feet*
Riverton Mine No. 1.........	72	43½	5	39	2	93	24	175
Barclay Coal Mining Co....	73	63	2	48½	?	89½	8	201
Williamsville Coal Co.	68	60	6	52	0	65½	18	179½
Test hole Springfield Colliery Co.	68	43½	0	62	0	54	?	160½
Springfield Colliery Co.	70	43	14	45½	3	76¾	24	169
Escape shaft Capitol Coal Co.	72	48½	0	56	0	58	24	164½
Spring Creek Coal Co.	72	41½	4	48½	2	79+	?	172
Boring ½ mi. SW. of Springfield	76	39	6	43	2	97	18	179½
Total averages	71	48	6	50	2	77	19½	175

COAL MINES

The mining of coal has been an important industry in the region under discussion since about the year 1860. The oldest mine operating in the area is mine No. 1 of the Springfield Coal Mining Company, at Riverton. Previous to the opening of this mine there were only drifts on coal No. 8. This bed was formerly worked at a number of places to the west, southeast and northeast of Springfield. The coal is said to be of good quality but is too thin to justify mining on a commercial scale.

Soon after the discovery of the thicker coal, No. 5, within easy working depth several shafts were put down and the coal industry rose to first importance. The output of coal in Sangamon County for the year 1910 aggregated 5,076,961 tons, being second only to the production in Williamson County for that year. The value of the coal at the mines was about $5,000,000. Much the greater part of this production was from mines located within the Springfield quadrangle. A large part of the coal is sold to the various railroads that pass through Springfield, and much of it finds a market at home.

All of the coal at present mined in the area is taken from coal No. 5. Thirty mines are in operation, all but two of which are commercial producers. There is given in the Table 38 a list of the coal mines of the quadrangle, the average thickness of the coal, the depth of the shaft and the altitude of the base of coal No. 5 in each mine.

TABLE 38.—*Coal mines in the Springfield quadrangle*

(All are operated on coal No. 5 by shaft openings.)

Table number	Company	Mine	Location					Coal No. 5			
			1/4	1/4	sec.	T. S.	R. W.	Map No.	Depth to base	Thickness	Source of information
									Feet	*Inches*	
1	Athens Coal Mining Co.	No. 2	NE	NE	1	17	6	1	212	75	M
2	Barclay Coal Mining Co..	Barclay	SW	SW	35	17	4	1	252	73	S
3	Capitol Coal Co.........	Capitol	NE	NW	35	16	5	1	226	72	M
4	Chicago & Springfield Coal Co.		SW	NW	12	16	5	1	235	74	M
5	Cantrall Cooperative Coal Co.	Cantrall	SE	NW	8	17	5	1	212	73	M
6	Citizens Coal Mining Co..	A	NW	NW	32	16	5	1	212	64	M
7	Citizens Coal Mining Co..	B	NW	SE	31	16	5	1	210	69	S
8	Cora Coal Mining Co....	No. 1	NW	SE	27	17	5	1	202	72	S
9	Jefferson Coal Co. (T. J. O'Gara)......	Jefferson	NW	SW	1	15	5	1	246	69	M
10	Illinois Colliery Co.....	No. 8	S½	SW	14	16	5	1	250	69	M
11	Illinois Midland Coal Co..	Peabody	SE	SE	36	17	5	1	204	72	M
12	[1]Lincoln Park Coal and Brick Co.		NW	SE	21	16	5	1	210	69	S
13	[1]Number 12 Coal Co.....		NE	SE	20	16	5	1	181	72	S
14	Sangamon Coal Co. Starnes No. 2 shaft...	No. 2	SW	SW	24	16	5	1	256	79	M
15	Spring Creek Coal Co...		NE	SE	19	16	5	1	173	72	M
16	Springfield Coal Mining Co. Riverton mine No. 1.	No. 1	SW	SE	9	16	4	1	230	69	M
17	Springfield Coal Mining Co. Riverton mine No. 2	No. 2	NW	SE	10	16	4	1	238	71	M
18	Springfield Coal Mining Co. Starnes No. 1 shaft	No. 3	NE	SW	24	16	5	2	245	69	S
19	Springfield Coal Mining Co.	No. 4	SW	SW	3	15	5	2	250	70	S
20	Springfield Coal Mining Co.	No. 5	SW	NW	9	15	5	1	256	71	M
21	Springfield Colliery Co..		N½	SW	13	16	5	1	231	73	M
22	Springfield Cooperative Coal Co.	No. 1	NW	NW	23	16	5	1	250	69	M
23	Standard Washed Coal Co.	No. 1	NE	SE	4	16	4	1	238	69	M
24	Standard Washed Coal Co.	No. 2	SW	SW	8	16	4	1	240	69	M
25	Tuxhorn Coal Mining Co.	Tuxhorn	NW	SW	5	15	4	1	230	68	M
26	Wabash Coal Co........	No. 2	SW	NW	36	18	6	1	206	72	M
27	West End Coal Co......		NE	NE	29	16	5	1	150	66	S
28	Williamsville Coal Co...	Selbytown	S½	NW	17	17	4	1	272	68	M
29	Wilmington and Springfield Coal Co. (Jones and Adams, C. C.)...	Republic	SW	SW	14	16	5	2	245	70	S
30	Woodside Coal Co.......		NW	SW	3	15	5	1	251	78	M

[1]Non-shipping mines.
M, Measured by Survey representative.
S, Information from Superintendent of mine.

A coal bed one foot thick is estimated to contain 1770 tons of coal per acre. Coal No. 5 averages nearly 6 feet thick. Assuming the average thickness to be 5 3/4 feet, this bed would contain 10,177 tons per acre. In the average mine about 66 per cent of the coal is hoisted, the balance being left in pillars, etc. This percentage would make 6,785 tons of coal per acre available under the present method of mining.

MINING METHODS AND EQUIPMENT

In the mines of this area all the coal is hoisted through shafts by steam engines working a 6- to 8-foot drum. The shafts are of two compartments, usually 6 or 8 feet by 14 or 16 feet, and are provided with automatic dumping cages. In some of the mines the framework of the shaft, tipple, and cages are of steel throughout. The coal is usually dumped over shaker screens and loaded on 2, 3, or 4 tracks. The top works of the newer mines are conveniently planned and substantially built.

A few of the operators have installed motor haulage. In some of the mines tail ropes are used, but in the greater number all of the mine haulage is done by mules on cars of 2000 to 3000 pounds capacity. The coal is generally shot from the solid without undercutting, no mining machines being used in the mines of the area. There is therefore considerable breaking up and waste of the coal in the process of mining.

Most of the coal is put on the market without washing. However, a washer has been installed by the Producers Coal Company, at mine No. 2 of the Standard Washed Coal Company at Bissell. The screenings from the No. 1 mine of the same company, at Spaulding, are also washed at this plant. All of the coal that passes through 3-inch shaker screens, which is about 60 per cent of all the coal hoisted, is sent to the washer.

The washer is equipped with two Stewart jigs which have a capacity of 100 tons per hour. Between 5 and 6 per cent of dirt is removed by the washing. Of the washed coal about 15 per cent is egg size, which does not pass through 2-inch revolving screens; about 20 per cent is nut, which passes over 1½ inch screens; and about 25 per cent is pea coal; and the remainder, about 40 per cent, is slack.

The room-and-pillar method and the panel system of mining are employed. The former was first in general practice, but at present the panel system which is a modification of the room-and-pillar, is followed in many of the mines.

By the panel system a mine is divided into districts or panels by driving entries and cross entries so as to intersect one another at regular intervals. Large pillars are left surrounding the workings in each panel within which any method of development may be used. The main entries are driven 10 to 12 feet wide according to the roof conditions, and the coal is taken out from roof shale to fire clay. Sixty-foot pillars are left on either side. The cross entries are about 500 feet long, and the "butt" or room-producing entries are about 1200 feet. This gives the distance of 1200 feet between the cross entries and makes the "butt" entries 500 feet apart. The rooms are 250 feet long, spaced at 40-foot centers along the entries. They are 30 feet wide, leaving a pillar 10 feet wide between the rooms. The first and the last rooms on each "butt" entry are spaced 60 feet center to center with the cross entries providing for a 40-foot pillar along the entries.

In general the roof conditions are good. The black shale usually stands well, and where this falls the cap rock makes a safe cover. Props and cross bars are set 3, 6, or 10 feet apart depending upon the local conditions of the roof. In many places but few timbers are needed in the entries, and they are usually placed not closer than 4 to 6 feet apart in the rooms.

Where the under clay is unusually thick, it has a tendency to creep and sometimes causes trouble from squeezes. However, the mines are uniformly dry and the under clay is usually so thin that trouble from this source is seldom experienced.

SAMPLING AND CHEMICAL ANALYSES OF COAL NO. 5

Samples of coal No. 5 for chemical analyses were collected from the mines designated by the table number 5, 6, 17, 20, 21, 24, 25, 28, and 30 in Table 39 operated in this area, and also from the mine of the Wabash Coal Co. at Dawson. The samples are thought to represent the average coal from the entire bed as it is taken from the mine. They were made by first cleaning the face of the coal and then cutting a narrow channel of uniform width and depth from the top to the bottom of the bed. The coal was caught on a canvas, broken sufficiently fine to pass through a sieve of ½-inch mesh, quartered down, and the sample placed in an air-tight mailing can before leaving the mine. Occasional sulphur lenses and bands, ⅜ inch or more in thickness, were excluded from the samples inasmuch as these are supposed to be thrown out of the coal by the miners.

The quality of coal No. 5 in this region may be seen from Table 39 of chemical analyses. The range of values and the average results for all of the samples are shown.

TABLE 39.—*Proximate analyses of coal No. 5 from Springfield quadrangle and vicinity*[a]

Lab. No.	Condition	Moisture	Fixed carbon	Volatile matter	Ash	Sulphur	B. t. u.
2782	As received	13.69	40.15	36.79	9.37	4.34	10,890
	Dry coal		46.52	42.62	10.86	5.05	12,618
2783	As received	14.40	39.58	36.45	9.57	4.15	10,804
	Dry coal		46.23	42.59	11.18	4.85	12,621
540	As received	13.56			9.29	4.13	11,019
	Dry coal				10.78	4.78	12,749
721	As received	14.39			11.68	3.95	10,534
	Dry coal				13.64	4.61	12,304
740	As received	14.30			10.91	3.52	10,598
	Dry coal				12.75	4.11	12,369
741	As received	13.13			10.83	3.72	10,785
	Dry coal				12.47	4.28	12,416
1761	As received	14.61	37.76	36.97	10.66	3.88	10,557
	Dry coal		44.22	43.30	12.48	4.55	12,364
1762	As received	14.55	38.06	36.41	10.97	3.88	10,493
	Dry coal		44.53	42.62	12.85	4.54	12,281
1766	As received	15.42	36.70	35.41	12.47	3.54	10,219
	Dry coal		43.39	41.88	14.73	4.19	12,082
1770	As received	14.89	37.15	38.32	9.64	4.08	10,778
	Dry coal		43.66	45.02	11.32	4.79	12,663
1772	As received	14.00	38.73	36.23	11.04	3.49	10,628
	Dry coal		45.04	42.13	12.83	4.06	12,358
1773	As received	14.44	38.73	37.26	10.03	4.15	10,675
	Dry coal		44.73	43.56	11.71	4.85	12,477
1774	As received	14.41	38.49	37.00	10.10	4.35	10,741
	Dry coal		44.98	43.22	11.80	5.09	12,550
1786	As received	14.18	37.84	35.39	12.59	4.29	10,396
	Dry coal		44.10	41.23	14.67	5.00	12,115
1790	As received	16.41	40.85	33.80	8.94	3.05	10,603
	Dry coal		48.87	40.44	10.69	3.65	12,685
1792	As received	15.38	39.51	36.52	8.59	3.38	10,873
	Dry coal		46.70	43.16	10.14	4.00	12,849
1794	As received	13.69	38.61	35.39	12.31	3.35	10,472
	Dry coal		44.74	41.00	14.26	3.88	12,133
1704 U. S.[b]	As received	13.89	40.89	33.96	11.26	3.83	10,636
1705 U. S.[b]	As received	14.45	40.10	34.79	10.66	3.46	

Analyses by J. M. Lindgren under the direction of S. W. Parr of the Ill. State Geol. Survey.

[a]First and second samples from Menard County; all others from Sangamon.

[b]Analyses made by U. S. Geological Survey.

Clay Resources

GENERAL STATEMENT

The only clay goods manufactured at present in the quadrangle consist of various grades of building, sidewalk, and paving brick. The total value of the output of the various kinds of brick in Sangamon County for the year 1910 was $75,012. Much the greater part of this was from wares produced in the vicinity of Springfield.

The raw materials in this area suitable for manufacture into clay goods are Pennsylvanian shale, and loess and alluvial clay of the surficial formations. Of the shale, two beds have been utilized. The lowest of these lies a short distance below coal No. 8, and the upper bed lies a few feet above its limestone cap rock. This inexhaustible supply of raw materials is of superior quality and easily accessible both as regards the overburden and the convenience to railroads. A cheap and abundant fuel supply is close at hand. The facilities for distributing and marketing the output are unusually favorable, and there seems to be no reason why this area may not become one of the most important centers in the Mississippi Valley for the production of clay wares.

SHALE BELOW COAL NO. 8

Some years ago Masters Brothers of Springfield operated a brick plant near the State Fair Grounds. The shale underlying coal No. 8 was mixed with the overlying surficial clay in the manufacture of various grades of brick. A thickness of about 15 feet of the shale was worked with about 8 feet of the loess. Coal No. 8 above the shale was used in burning the clay. The product was said to be of good quality, and the plant continued in successful operation for several years.

In the western part of Springfield the Dawson Brick and Tile Company are manufacturing brick for which this lower bed of shale is used in connection with surface clays. A section of the pit of this company is given below:

Section of clay pit of Dawson Brick and Tile Company

	Feet
5. Soil and loess	12
4. Clay, yellow, in places much iron stained, with numerous small pebbles	6
3. Sand, coarse, water-bearing	1½
2. Till, bluish-gray, somewhat sandy, with bowlders of various sizes up to 4 feet in diameter	16
1. Shale, brown to blue (Pennsylvanian)	7

The shale in the foregoing section lies 10 or 12 feet below coal No. 8. About 25 per cent of the shale and 75 per cent of surface materials comprise the mixture from which the ware is made. The pebbles and gravel of the drift are screened out and sold for a sum sufficient to cover the expense of their removal. Common building brick, the only kind made at present, is manufactured by the stiff-mud process. A J. C. steel auger machine is used with a pug mill, the two requiring about 40-horse power to operate them. The clay is ground to a fineness of 1/4 to 1/16 of an inch. If the grinding is made much finer than this, it is said to cause trouble in the checking or cracking of the brick. The direct heat used in drying makes the brick dirty, but the quality of the production is fair. This system of drying would seem to be bad from a standpoint of fuel economy, but the price of the coal used for this purpose is only 65 cents per ton, which makes the fuel expense so small that it has seemed undesirable to install a system of drying with waste heat.

The burning is made in two, double, down-draft, rectangular kilns and two clamp kilns, having a total capacity of 600,000 brick. The drying requires about two weeks and the burn occupies 10 to 11 days after water smoking. The fuel expense is estimated at one dollar per thousand brick, two-thirds of the coal used costing 65 cents, and the remaining one-third costing one and one-half dollars per ton. The total yearly production of brick is about 4,000,000. Almost the entire output is marketed in the city of Springfield.

SHALE ABOVE COAL NO. 8

The Springfield Paving Brick Company works the bed of shale overlying the cap rock above coal No. 8. A thickness of 44 feet of shale has been utilized at this place. It is mined with a steam shovel and drawn to the works with drum and cable. Four to twelve feet of the overlying loess is used with the shale in the clay mixture. The shale is dark gray, rather fine grained, thin bedded, and quite hard. Two Peterson and one Penfield dry pans are used in grinding the shale, which is reduced to a fineness of 1/8 to 3/8 inches. The clay is tempered in a Penfield pug mill. About 12 per cent water is needed to give it the requisite plasticity. A Chambers auger and end-cut brick machine is used. A force of 20-horse power is required for pugging, and 85-horse power in forcing the bar of clay through the die. Soon after emerging from the die, blisters rise on the surface of the clay bar at frequent intervals. These blistered spots are points of weakness in the pavers, and have caused considerable annoyance. The superintendent of the company, R. H. Staley, thinks they are due to bubbles of air being present within the bar of clay. On the relief of pressure, after coming from the die, this air expands and raises the surface into blisters. To remedy this Mr. Staley plans to have the clay from the pug mill pass into a vacuum chamber where it will be cut up and the air removed before the clay is forced through the die. This experiment had not been tried at the time this study was made.

A waste-heat drying system is installed, consisting of ten fireproof tunnels constructed of brick and cement, which accomodate 20 tracks. The brick are burned in rectangular, down-draft kilns, built on a plan modified for the yard. For distributing the heat a large tunnel is used, supplied with four stacks, one on each side and one at each end. About seven days are required for water smoking and burning. The total

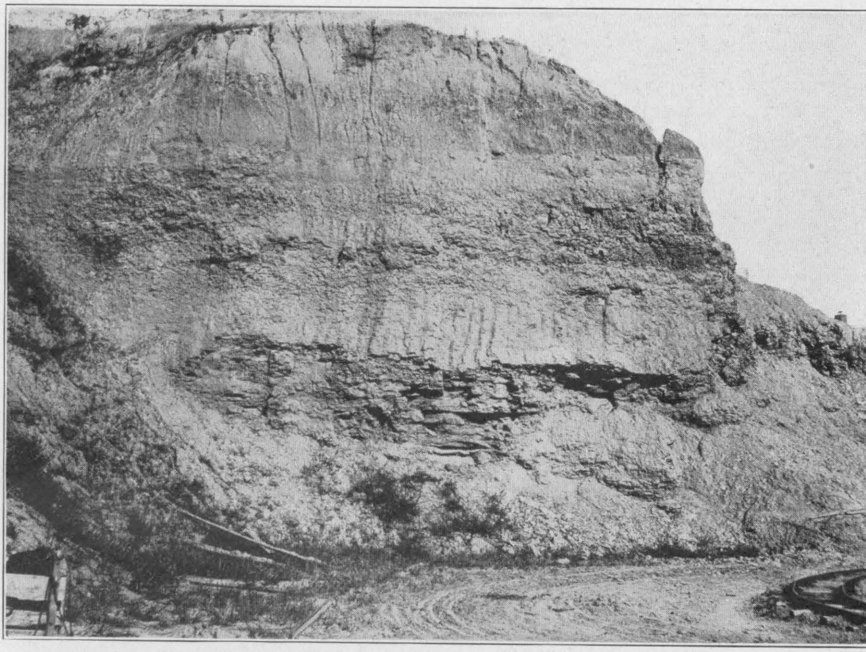


FIG. 4. Shale, overlying limestone above coal No. 8, exposed in shale pit of Springfield Paving Brick Co., Springfield.

shrinkage of the brick in drying and burning is estimated at 12 per cent. About 1½ tons of mine-run coal are used in the manufacture of 1000 brick.

The output of this plant consists of paving brick, sidewalk brick, and builders, of which a yearly total of about 18,000,000 is produced. The rejects of the pavers are sold as builders, and those in the more poorly burned parts of the kilns are sold for sidewalk brick. In this manner there is very little waste, and the quality of all is superior. In the various tests of paving brick made by Professor A. N. Talbot of the

University of Illinois, the pavers made by the Springfield Paving Brick Company compared very favorably indeed with those made by other paving brick manufacturers in Illinois and neighboring states. For the detailed results of these tests the reader is referred to Professor Talbot's[1] paper.

There is a large demand for the output of this company in the city of Springfield. Large quantities of the brick are also sent to other cities in central Illinois, and to St. Louis. Pavers are shipped north as far as Duluth and south as far as New Orleans.

SURFACE CLAYS

For several years the Lincoln Park Coal and Brick Company have operated a brick yard in connection with their coal mine. Common brick and face brick are made from loess clay by the dry-press process. Quincy gatherers are used, and revolving disk plows for cutting up the top. The plant is equipped with a Ross Keller disintegrator and press. Some trouble is experienced with "pressure cracks" unless the kiln is cooled very slowly. The brick are burned in round, down-draft kilns with riddle bottoms. The length of burn is about 14 days at a temperature of about 1742° F. In general the loess clay is said to require a higher temperature for burning than the shale. The estimated amount of fuel required per thousand brick is a little less than one ton. The yearly output of the plant is about 2,000,000 brick, all of which find a market in Springfield.

Common building brick are also manufactured by Mr. P. M. Bartelme at Springfield by the stiff-mud process, the loess being used as the raw material. The plant is equipped with a Freese combined pug mill and brick machine. There is a tendency to lamination in the brick which is thought to be due to the resistance of the sides of the die above that of the center, thus some slipping results. The trouble is obviated by placing pins in front of the auger so that the middle part of the clay core will be cut up and thus encounter resistance somewhat equal to that of the sides. Drying is done with direct heat. The burn is made in round, down-draft kilns, requiring $1\frac{1}{4}$ to $1\frac{1}{2}$ tons of coal per thousand brick. The total annual output is $3,500,000, all of which are put on the local market.

A short distance north of Athens, Mr. J. C. Cronister manufactures common brick from loess clay. The brick are moulded by hand, and kilns are burned as the local market demands.

[1]Talbot, A. N., Qualities of high grade paving brick and tests in determining them: Ill. State Geol. Survey Bull. 9, pp. 47 et seq. 1908.

THE VALUATION OF COAL FOR GAS MANUFACTURE

By S. W. Parr

OUTLINE

TABLES

VALUATION OF COAL FOR GAS MANUFACTURE

INTRODUCTION

Doubtless the value of coal for the manufacture of city gas can be determined in its ultimate phases only by an actual test in the retorts, since many of the properties are more or less directly dependent upon temperatures of distillation, size of the charge, type of retort, and other factors. However, the question is a proper one to raise as to what information may be had from an analysis of the coal. It is perhaps a just criticism of chemical analyses, so far as gas, manufacture is concerned, to say that they afford very little information as to the relative value of coals for this purpose. The aim of this paper is to indicate whether values which may be obtained from the ordinary proximate analysis and which are not ordinarily put in a form for interpretation may serve the more definite function of indicating relative adaptability of coals for gas making.

INTERPRETATION OF PROXIMATE ANALYSIS

DETERMINATION OF CORRECTED VOLATILE MATTER

It would seem as though an Illinois coal with 35 per cent volatile matter should result in as good a yield per pound as a West Virginia or Pennsylvania coal with 35 per cent volatile matter. However, the volatile constituents in the two types of coal, as is well known, vary with respect to the content of oxygen or inert material present, a feature which has already been set forth.[1] This inert volatile matter of the eastern bituminous coals is less than half as much as is found in the Illinois coals.

These facts ordinarily may be deduced from an ultimate analysis of the coal; but a much more convenient source of information may be found in the proximate analysis if we concede the following facts: *First,* that a fairly accurate determination of the volatile matter can be made. The endeavor to solve this problem has been made by certain improvements in procedure, which will bring that determination up to a point of greater accuracy. *Second,* the possibility of deriving a corrected ash value, as detailed in a previous report[2] permits the deduction of a corrected volatile matter, since the error in the ash is due to such volatile constituents as sulphur and water of hydration, which, unless corrected for, augment by so much the volatile factor. By application of the im-

[1]Parr, S. W., A chemical study of Illinois coals: Illinois Coal Mining Investigations Bull. 3 (in press).

[2]Parr, S. W., Composition of Illinois coal: Ill. Geol. Survey Bull. 16, pp. 210-212, 1910.

proved method thus outlined in Bulletin 16, it is possible to obtain the heat value for unit carbon and also the heat value for unit volatile matter, and by means of this latter factor there may be derived the heat values to be credited per pound to the true or volatile matter in any type of coal. This at once indicates the relative value of such a coal for gas-making purposes. That is to say, the inert or non-combustible part of the volatile matter modifies its heat value; the higher the oxygen, or the combined water content, the lower will be the heat value per pound of volatile matter; and conversely, the lower the oxygen or inert volatile matter, the higher will be the indicated heat value per pound of that substance.

An illustration of the application of these principles will explain more definitely what is meant. For example, a sample of coal from Williamson County, Illinois (Lab. No. 1918), has the following constituents:

Dry-coal analysis of coal from Williamson County

Ash as weighed	9.50
Volatile matter	34.89
Fixed carbon	55.61
Sulphur	1.75
B. t. u.	13,173
Unit coal	14,739

Corrected ash, as obtained by the formula,[1] Ash=1.08 A+½ S + 1/20 S, gives a corrected ash of 11.22 per cent. Now, it must be evident that this correction to the ash is volatile matter, which in the process of analysis is regarded as belonging to the latter factor instead of to the ash where it properly belongs. The percentage of volatile matter, therefore, should be corrected by the amount of error derived for the ash; namely 11.22 — 9.50 or 1.72 per cent.

DEDUCTION OF HEAT VALUES

The proper distribution of this error, however, makes no difference in the fixed carbon, the percentage, 55.61, remaining the same, however the errors as to volatile matter and ash are distributed. The amount of fixed carbon in unit coal, therefore, would be found by the expression $\frac{55.61}{100 - 11.22}$ =62.63 per cent of unit carbon. By difference between this value and 100 we have 37.37 which represents the percentage of unit volatile matter. These two substances combine to form what is termed *unit coal,* which has a value, as taken from the table, of 14,739 B. t. u. per pound. We can now distribute these values, as between the unit carbon and the unit volatile matter, thus: The known factor for one pound of carbon is 14,544. Hence, 62.63 per cent of carbon, as in the

[1]Loc. cit.

unit substance of this coal, gives 9,109 B. t. u. Subtracting this from the unit coal value, 14,739, we have 5,630 B. t. u. for the 37.37 per cent of volatile matter. Then, 1 pound of unit volatile matter= $\frac{5630}{37.37} \times 100=15{,}065$ B. t. u. Hence, the value of a pound of pure or corrected volatile matter of Williamson County coal, sample No. 1918, is 15,065 units.

Now, if we compare with this a coal from West Virginia (Lab. No. 4133) with composition of the dry coal as below,

Dry-coal analysis of coal from West Virginia

Ash as weighed	10.12
Volatile matter	34.74
Fixed carbon	55.14
Sulphur	2.28
B. t. u.	13,600
Unit coal	15,359

Making the same calculations, we will find the heat value for the calculated percentage of carbon in the unit coal, 62.78, to be 9,131 B. t. u., and the percentage of the remaining volatile matter, 37.22, is 6,228 B. t. u. Calculating this latter value to the unit or pound basis, $\frac{6{,}228}{37.22} \times 100=$ 16,732 B. t. u. That is to say, two coals, one having 34.89 per cent of volatile matter as regularly determined on the dry coal basis and the other 34.74 per cent, show relative heat values per pound of unit volatile matter of 15,065 B. t. u. and 16,732 B. t. u. respectively. The higher heat value of the West Virginia coal is due to the lower amount of inert volatile matter in its composition. Conversely, the higher inert volatile matter of the Illinois coal shows itself in the relatively lower amount of heat value which is contained in the unit of reference; namely, the one pound of unit volatile matter as above outlined.

A number of coals regularly used for gas-making purposes have recently been observed, and their results calculated and tabulated with reference to their volatile matter as shown below in Table 40. They are arranged in relative order with reference to the heat value per pound of volatile substance, and are shown to differ in an interesting manner. It should be stated further that these differences are to be interpreted as being in amounts of yield rather than in richness of the gas, for the reason as already explained that the lower heat values result from higher inert constituents, such as water of composition, which by analysis must be reckoned as part of the volatile matter but which because of its condensible character lessens the volume of the permanent gases. By the conditions of analysis and calculation, however, the heat value is made to refer to the entire condensible and non-condensible substance, which is frequently designated as volatile combustible or in this paper simply as volatile matter.

Attention is called again to the fact that the values in the last column of Table 40 refer to a pound of volatile substance as the unit of comparison. Only by basing the values upon such a unit of reference can we gain an idea of the character of the volatile matter in any given sample.

Of course, it will also be desirable in any case to be able to make comparison between the heat value of the volatile matter per pound of the coal as delivered, as a knowledge of relative cost may be desired rather than a study of the type or character of the volatile matter present. This is readily indicated by the following calculation:

Referring again to the Williamson County coal (No. 1918) the heat value on the dry-coal basis of the fixed carbon present, calculated at 14,544 B. t. u. per pound, would be $55.61 \times 14{,}544 = 8088$ B. t. u. This would leave for the volatile matter of the coal a value of $13{,}173 - (8{,}088 + 5000S)$, S being the sulphur, with a heat value of 87 B. t. u. Hence we have $13{,}173 - 8{,}175 = 4{,}998$. This latter factor 4,998 shows the heat value of the volatile matter which is present in each pound of coal, and does not afford any basis of comparison as between the property or compositions of different volatile substances themselves. The factor as thus derived is affected by such variables as ash. Hence a comparison on the dry basis, between coals as actually used is shown by Table 41. The column showing the heat-unit values for the percentage of volatile matter present is arranged in the order of their relative worth per pound of coal and the next column gives the value per pound of the unit volatile matter for comparison. Generally they correspond as to order; but the variations in the quantity of volatile matter, such as an unusually high percentage, in some instances overcome the discrepancies in composition, and the order is reversed. This is notably the case, for example, with coal No. 4127.

Attention may also be called to the fact that values for the pound unit of volatile matter may be obtained by dividing 4,998 by the corrected volatile matter and multiplying by 100; thus, $\frac{4{,}998}{34.89 - 1.72} \times 100 = 15{,}068$.

TABLE 40.—*Proximate analyses and heat values of fixed carbon and volatile matter in some coal samples*

Lab. No.	Proximate analysis of dry coal				Per cent of unit fixed carbon	Per cent of unit volatile matter	B. t. u. per pound of unit coal	B. t. u. unit fixed carbon	B. t. u. unit volatile matter	B. t. u. per pound unit volatile matter
	Fixed carbon	Volatile matter	Ash	Sulphur						
1723	53.88	37.34	8.78	1.21	60.00	40.00	14,595	8726	5869	14,672
1800	55.25	34.53	10.22	.68	62.36	37.64	14,603	9069	5534	14,700
1088	52.52	36.83	10.65	2.50	60.28	39.72	14,795	8767	6028	15,151
4127	49.87	41.19	8.94	1.83	55.89	44.11	14,962	8129	6833	15,480
1116	53.39	36.72	9.89	2.37	60.65	39.35	14,973	8820	6153	15,636
4122	57.25	35.80	6.96	1.08	62.26	37.74	15,267	9104	6163	16,330
4133	55.14	34.74	10.12	2.28	62.79	37.21	15,356	9131	6225	16,725
4134	57.47	35.14	7.39	1.25	62.91	37.09	15,425	9150	6275	16,918
4186	57.42	37.53	5.04	.87	61.03	38.97	15,527	8876	6651	17,066
4126	52.82	33.86	13.32	.86	62.04	37.96	15,505	9021	6484	17,081
4185	59.02	36.58	4.41	.78	62.25	37.75	15,509	9054	6455	17,099
4132	56.84	33.69	9.46	1.10	63.73	36.27	15,509	9268	6241	17,207
4128	54.59	35.36	10.05	1.71	61.89	38.11	15,562	9001	6561	17,216
4125	57.70	35.10	7.20	1.16	62.99	37.01	15,595	9161	6434	17,384

TABLE 41.—*Comparison of heat values per pound of volatile matter and heat values of volatile matter per pound of coal*

Lab. No.	Dry coal			B. t. u. per pound volatile matter	B. t. u. volatile matter per pound of coal
	Fixed carbon	Volatile matter	B. t. u.		
1088	52.52	36.83	13,016	15,151	4,243
1800	55.25	34.53	12,970	14,700	4,901
1723	53.88	37.34	13,173	14,672	5,277
1116	53.39	36.72	13,298	15,636	5,415
4133	55.14	34.74	13,600	16,725	5,467
4126	52.82	33.86	13,246	17,081	5,521
4132	56.84	33.69	13,886	17,207	5,565
4134	57.47	35.14	14,151	16,918	5,731
4128	54.59	35.36	13,812	17,216	5,789
4125	57.70	35.10	14,342	17,384	5,892
4127	49.87	41.19	13,463	15,480	6,119
4185	59.02	36.58	14,743	17,099	6,120
4186	57.42	37.53	14,649	17,066	6,255

NEWLY DISCOVERED BEDS OF EXTINCT LAKES IN SOUTHERN AND WESTERN ILLINOIS AND ADJACENT STATES

By E. W. Shaw

U. S. GEOLOGICAL SURVEY
(IN COOPERATION WITH STATE GEOLOGICAL SURVEY)

OUTLINE

ILLUSTRATIONS

NEWLY DISCOVERED BEDS OF EXTINCT LAKES IN SOUTHERN AND WESTERN ILLINOIS AND ADJACENT STATES

PROBLEMS OF LOWLAND DEPOSITS OF SOUTHERN AND WESTERN ILLINOIS

Streams and stream work in the middle part of the Mississippi basin have several interesting peculiarities. The broad, swampy, bottom land is thickly forested, or where cleared presents a tangle of tall weeds, or dense fields of corn. There is, however, more diversity in the surface features of the lowland than is evident at first sight, and the deep stream channels and washes expose a variety of unconsolidated materials, consisting chiefly, however, only of different kinds of mud, clay, and sandy clay. The present paper treats one of several problems relative to the physiography of the Ohio and central Mississippi valleys—that of extinct lakes in the valleys of tributaries of the Ohio and Mississippi.

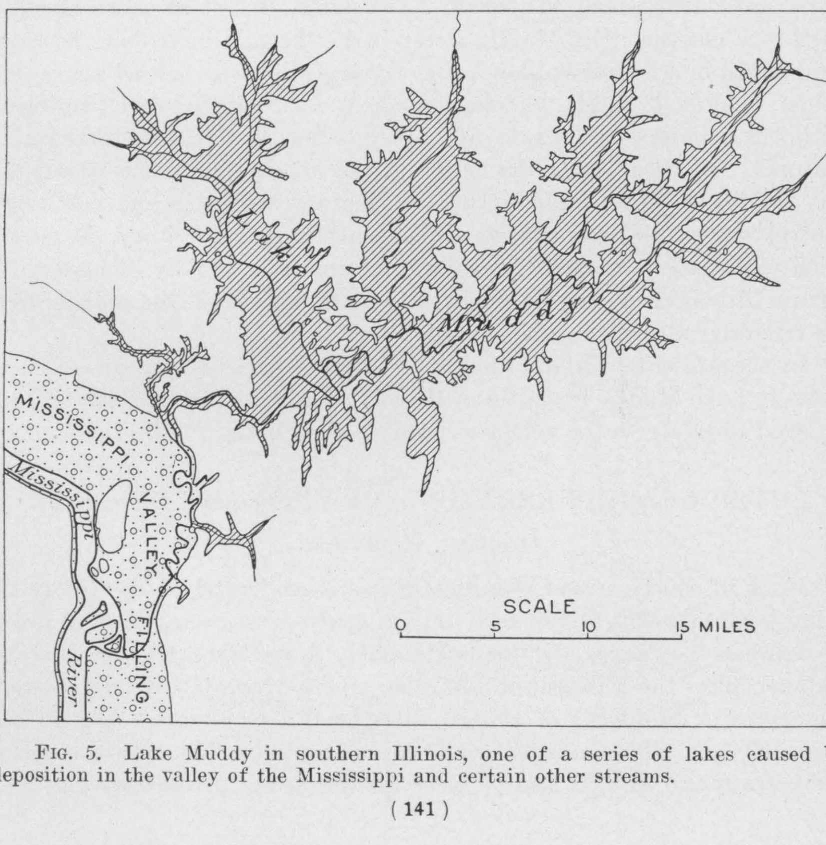


FIG. 5. Lake Muddy in southern Illinois, one of a series of lakes caused by deposition in the valley of the Mississippi and certain other streams.

The first lake beds to be discovered were in southern Illinois; and the lake whose certain existence was first demonstrated lay in the basin of Big Muddy River (fig. 5). The outlines of extinct lakes in southern Illinois are somewhat obscure for several reasons: shore features were only slightly developed; the country is so little dissected that exposures of the lake deposits are few; more important still,—since the lakes covered only the lowest areas of the lowland the flat surfaces of the lake deposits are not in contrast to the surrounding land, which is also nearly flat. In western Kentucky and eastern Missouri, however, relief is generally greater, and the flat surfaces of the lake deposits stand out in marked contrast to the bordering hills.

The writer believes that the lakes were formed on tributaries of the Mississippi and Ohio because of the rapid filling of the channels of the master streams so as to form dams across the mouths of the tributaries.

The lower half or third of each tributary, except the smaller ones, flows over a thick, unconsolidated mass, which is similar to that on the larger stream, except that it is generally less coarse. The Wisconsin River in southwestern Wisconsin is working 50 feet or more above a hard-rock channel; Big Muddy River in southern Illinois flows between mud banks in a broad, shallow valley having a buried channel many feet below; in Pennsylvania, the Monongahela does not flow over bed rock within the limits of the State, and other tributary streams show similar features. Thus, not only the valley of the Mississippi and of the Ohio, but the lower part of almost every tributary valley in the northeast-central states, and presumably in a much larger territory, is partly filled with loose sediment. The filling comprises a variety of materials; but in Illinois, Indiana, Kentucky, Missouri, and Iowa, the sediment on the tributary streams consists mainly of clay.

In the presentation and analysis of the evidence special attention is given to Lake Muddy in southern Illinois (fig. 5) but the conclusions are believed to apply to the whole series of extinct lakes.

PHYSIOGRAPHIC RELATIONS OF THE LAKE DEPOSITS

General Relations

Much of southern and western Illinois is moderately hilly, the relief being generally 200 to 300 feet; but extensive, irregular, lowland areas lie between the ranges of hills, particularly in southern Illinois, at some distance from the Mississippi and Ohio rivers, where many areas covering scores or hundreds of square miles have a maximum relief of less than 100 feet. These are the old lake beds modified by recent erosion. They are found as flats and terraces bordering the present streams and

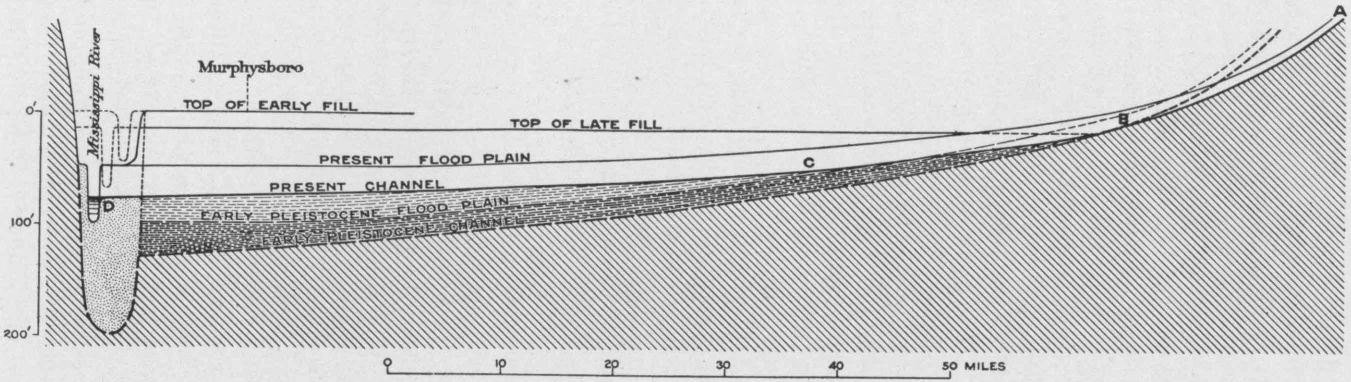


FIG. 6. Longitudinal section of deposits of Big Muddy River and cross-section of deposits of Mississippi River. Most of the filling material in Big Muddy Valley, like that in many others, is silt and clay, in part fluvial, and in part lacustrine. The filling is in fact double, and the top of the early filling, like that of the late one, is horizontal. The lower end of the present flood plain is practically horizontal, and high above the present channel bottom, the distance being controlled by the range between high and low water of the Mississippi. In order to show the profiles correctly, the section was made along the whole crooked course of Big Muddy River, and not in a direct line from source to mouth.

are related to certain abnormal features of the stream profiles and unusual shapes of the valley flats.

The upper surface of the lake deposit forms a terrace, so broad and so low that it is scarcely perceptible, although commonly separated from the flood plain by a low scarp. This terrace is almost horizontal, and since the flood plain rises upstream, the terrace and flood plain approach in that direction and finally merge. However, the flood plain itself is nearly horizontal (for the streams have little fall), and the flood plain and terrace of some rivers are distinct for 40 miles or more.

Considering the valleys lengthwise (fig. 6), the upper part of each (A-B) seems normal, but a middle portion (B-C) at the head of the lake fill where it merges with the flood plain, is broad and swampy. The gradient in the lower valley (C-D) is extremely gentle. When the lakes were first permanently drained the profile of each stream was sloping in the upper part, and horizontal in the lower where the fill was. Since then the stream has been cutting into the lower end of the fill as rapidly as the master stream would allow and building up the upper end of the fill in its attempt to smooth out the kink in its profile produced by the valley filling.

Even the very smallest of the streamlets which cross the fill have been doing a similar work, so that the edges of the fill are commonly built a little above the general flat surface, and much of this additional material seems to be rainwash.

One of the related characteristics of these valleys is the shape of the flood plain. In the first division it is of ordinary width; in the second it is very broad; and in the third it is very narrow. The reasons are readily explained: The upper stream courses have not been affected by the ponding and consequently the shape of the valleys is not unusual. In the central parts of the streams downward-cutting was checked by the ponding, and this, together with some filling, helped to give breadth to the flood plain after the lakes were drained. Along the lower stream courses, a similar effect was produced by the filling, except that it was thicker; and the top, which formed a flood plain when the lakes were drained, was even broader. Now, however, the streams have cut into this broader part, and developed new flood plains at a lower position, and these are narrow because they are young. These features are shown diagrammatically in figure 7.

Details from Big Muddy Valley

The valleys and streams tributary to the Mississippi and Ohio are thus similar in certain characteristics by which each may be separated into three natural divisions. Big Muddy may be considered a type and described in detail. It rises at an altitude of about 500 feet on the dividing line between Jefferson and Marion counties, flows south through Jefferson, Franklin, Williamson, and Jackson counties, and discharges into the Mississippi in the northwest corner of Union County at a low-water

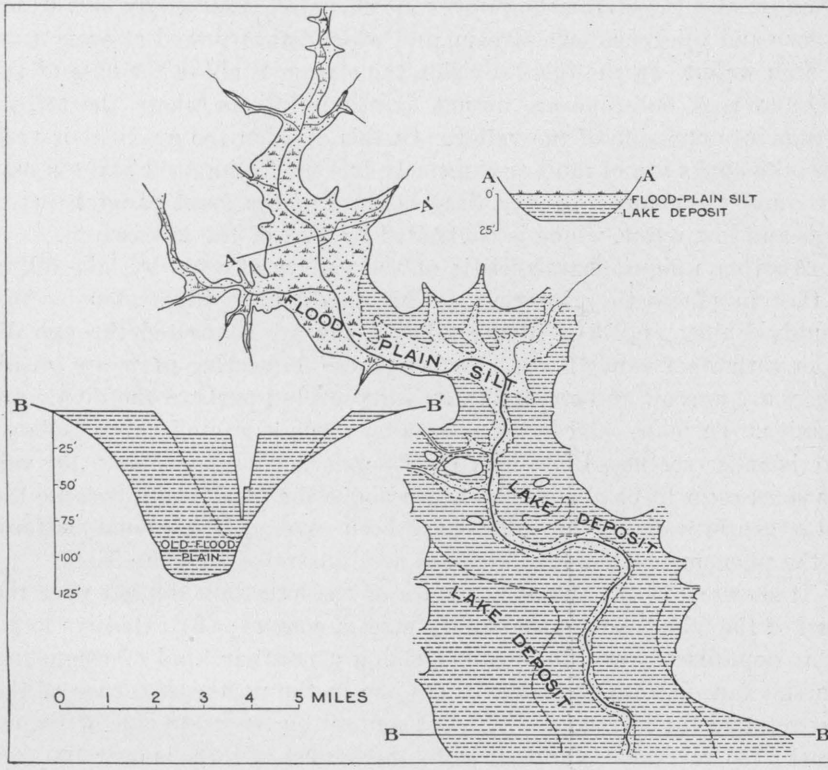


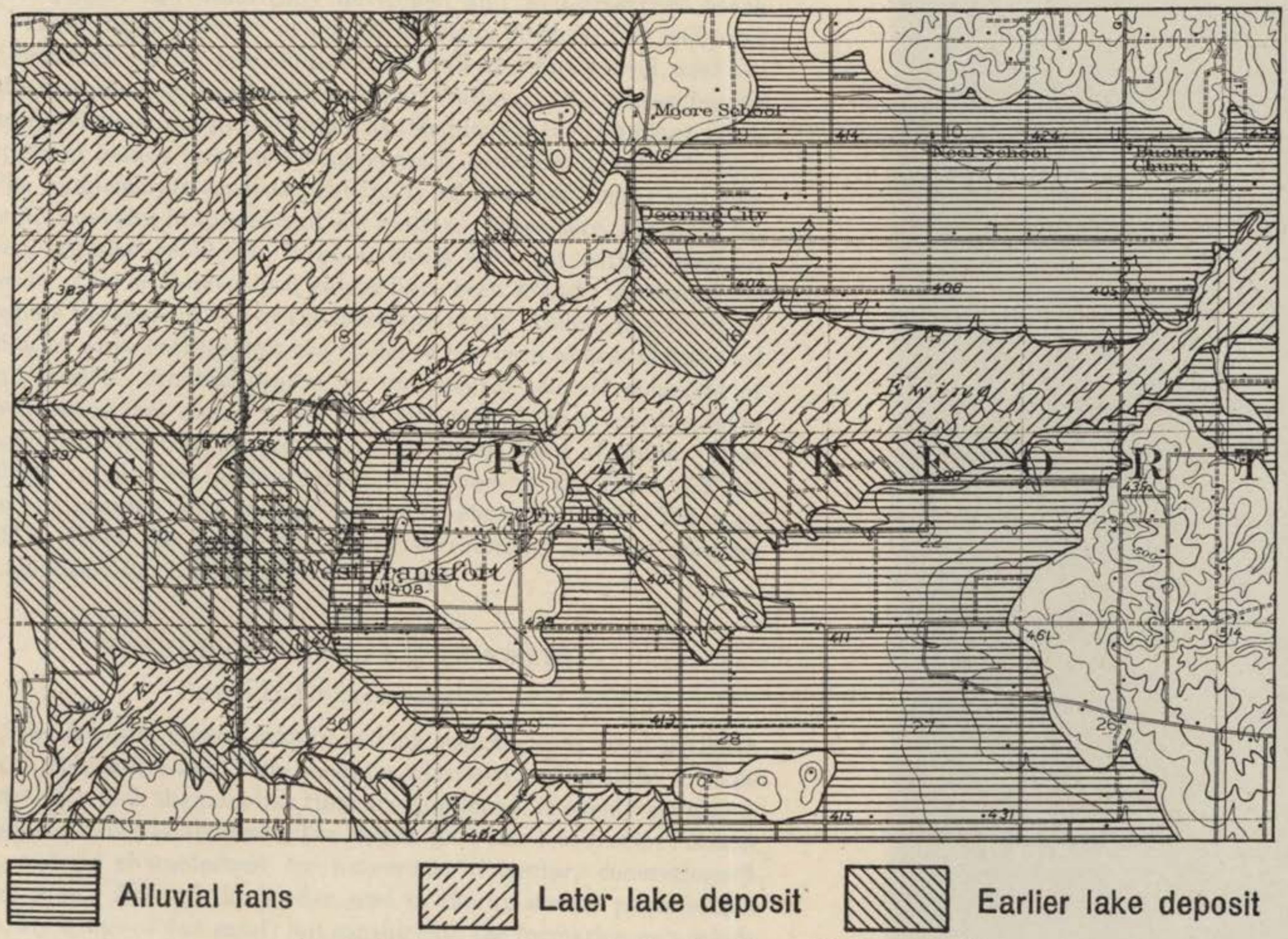
FIG. 7. Arrangement of principal deposits and surface features along Beaucoup Creek, Perry, and Jackson counties, Illinois. The filling thickens, and the flood plain becomes narrower down stream. When the lake became extinct, the bed became a great swamp. The stream first cut into the lower end of the fill, draining that part of the swamp, and developing a narrow flood plain below the surface of the lake silt. With further downward cutting, the new flood plain was lowered, and extended up stream, and the swamp area was reduced. Meanwhile, stream deposits continued to accumulate at the upper end of the lake bed. Many other valley bottoms are similar to this one, in having a swampy, central portion.

altitude of 325 feet. Its mid-stream length is about 135 miles, and its total fall is about 270 feet. In the first 20 miles, the fall is about 100 feet, or 5 feet to the mile; in the next 28 miles, the fall is 40 feet, or less than $1\frac{1}{2}$ feet to the mile; in the third division, the stream falls 35 feet in 87 miles, or less than 5 inches to the mile. The remarkably gentle gradient in the lower part of the stream is less than the gradient of the Mississippi, which flows nearby, and which has a fall of fully 7 inches to the mile.

In the first division the valley seems normal in all respects, and rock outcrops are numerous. In the second, the valley is broader, the bottom swampy, and the stream flows over an unconsolidated sandy silt, which widens and thickens down stream, and which is overflowed at every time of high water. In the third division the stream is above the base of the fill, and rock outcrops are absent except in places where the stream swings into one side of the valley. In this division the gradient is very low; the banks are of mud or extremely fine sand; the flood plain is narrow; and the channel is very deep because of the great range between high and low water, which is controlled by that of the Mississippi.

Another unique characteristic of the valleys affected by lake filling is that in places they interlace. This condition is illustrated by Big Muddy Valley (fig. 5). Many valley floors are connected through divides with other valley floors. Some of these connecting parts are broad, others are narrow and strait-like, and the severed parts of the divide are massive. In many places the flat valley floor surrounds hills, isolated like islands (see also Plate XIV). Though bare cliffs are few, the valley sides seem to be abnormally steep above the flood plain, because the lower gentle walls of the valley have been covered by alluvium. Many of the phenomena thus far described are illustrated in Plate XIII.

It shows: (1) the swampy surface of the later lake deposit near the head of the lake or along the middle stream courses; (2) extensive lenticular deposits of very fine wash, forming a peculiar kind of compound alluvial fan. (Note particularly the one in the northeast corner of the district, and the form of the 400-foot contour on the north side of Ewing Creek; (3) several "Island Hills,"—the largest of these is over 100 feet in height, and bears the old town of Frankfort, about 1½ miles east of West Frankfort. These hills, now surrounded by flat-surfaced lake deposits, were formerly islands; (4) at least one change in drainage due to lake deposits, for the creek flowing out of the southwest corner of the district once flowed northward and out through the northeast corner. Note the narrow valley of this stream along its present course, and compare with the former route indicated by the broad, flat surface of the earlier lake deposit just west of West Frankfort. Attempts to sink coal shafts at that place have been abandoned on account of quicksand.



Topographic and geologic map of West Frankfort, Illinois, and vicinity

The alluvial fans are composed of loess, washed down and spread over the foot of the hills and over the edge of the lake deposits, the altitude of which is 395 to 460 feet. The later lake deposit is principally clay, bearing up-stream a thin coat of stream alluvium, the altitude of this surface being 385 to 395 feet. The earlier lake deposit, which is fine sand with some clay, is partly buried under wash and stream alluvium. The altitude of this surface is 395 to 410 feet. The unshaded portions represent areas which stand higher than the stream and lake deposits, and which are hills of consolidated rock bearing a mantle of glacial till overlain by loess.

SHORE FEATURES OF THE LAKES

Shore features were generally poorly developed, though 12 to 15 miles northeast of Madisonville, Kentucky, 50 miles by water from the Ohio River, there are beautifully developed and well-preserved beach ridges. These ridges are very symmetrical, being 20 to 50 feet wide and 8 to 10 feet high. They are composed of sand and fine gravel, and are situated across the mouths of small tributary valleys. One reason for the excellent development of gravel ridges at this place is the abundant available supply of loosely cemented conglomerate, probably of late Tertiary age. The conglomerate consists principally of rounded quartz and subangular flint pebbles in a sand and silt matrix. Elsewhere, probably because well-rounded pebbles in large amounts were not within reach of the lakes no other well-developed ridges have been found. At numerous places where the bank of one of the lakes was easily eroded, there is some suggestion of wave cutting, but the evidence has been almost obliterated by recent erosion. Another reason for the general poor development of shore features is that owing to the rise and fall of the rivers the lakes were continually fluctuating and were even intermittent at times. Thus particularly in districts of low relief, the shores of the lakes did not stand in one position long enough to develop shore features. The map (Pl. XIV) shows the beach ridges and surrounding surface features east of Madisonville, Kentucky.

NATURE OF THE LAKE DEPOSITS

Physical Characteristics

The lake deposits consist mainly of clay which varies from greenish gray to purple gray, and from medium plasticity to "gumbo." The lower part, in which the purplish tints are developed, is evenly stratified, and in places finely laminated. The upper part has less distinct stratification, and is characterized by numerous, irregular, concretionary masses of lime. Around the border, and in the up-stream parts of the deposits, are lenses of fine sand; but considering the formation as a whole sand forms a remarkably small part. With the exception of the concretionary lime, some particles of which are as small as sand grains, most of the deposit is without perceptible grit. In ground plan, the bodies of clay are very irregular and even interlacing, a condition which would be expected of valley fills in a country of medium to low relief. The surface of the clay in each valley is horizontal, and lies 5 to 75 feet above low water, but the altitude varies from valley to valley. Near Cairo the surface of the clay is 345 feet above sea level; at Galena, Illinois, 400 miles up the Mississippi, it is 650 feet; and there is a corresponding increase in altitude up the Ohio.

Thus, although the clay in each tributary valley and its branches is usually isolated and lies at a different altitude from that in every other valley, the different bodies have so regular an arrangement and so many characteristics in common, that there can be little question as to their close relationship and probable origin as lake deposits. Exposures of the clay are to be found at the mouth of each tributary, along stream courses, in wells, and coal shafts. Most of the lakes were nearly filled with sediment before the main streams began to cut down again. Now, however, the tributary streams have cut narrow trenches which deepen down stream and expose in some places as much as 40 feet of the lake deposit.

Fossils

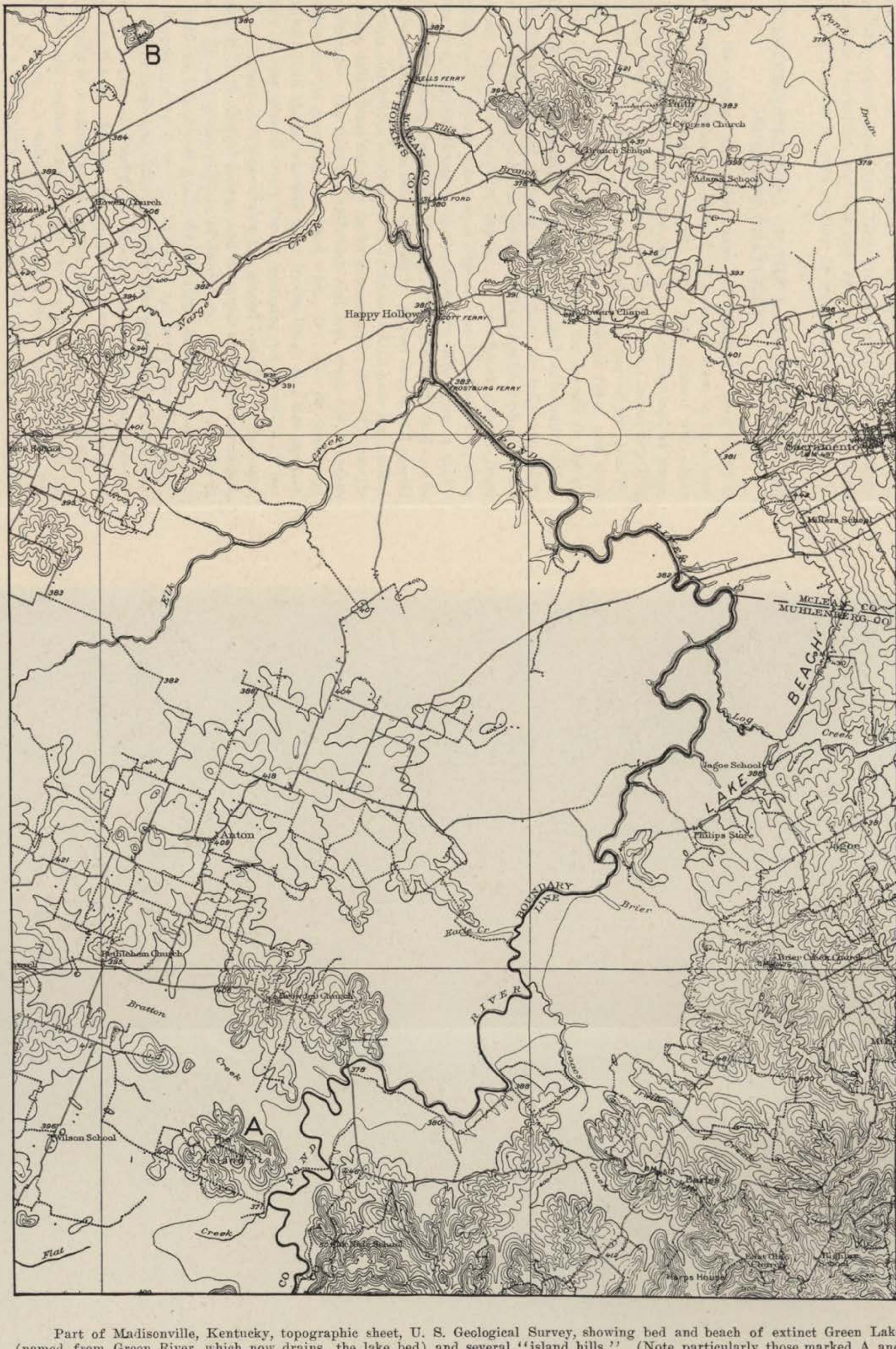
Good collections of fossils were obtained, the fauna consisting of nearly a score of species of gastropods, and lamellibranchs; and, undoubtedly, further search might reveal many more species, including perhaps vertebrate and plant remains. Most of the forms collected were those which inhabit lagoons and the quiet parts of streams. One, *Campeloma,* is a scavenger living on decaying matter. Others, particularly *Amnicola* and *Valvata,* frequent lily ponds. Some, such as *Vertigo,* are northern forms such as are found at present from Wisconsin northward. *Sphaerium* is found today on the mud bottoms of pools throughout a large territory. The following fossils of aquatic species were collected at two localities on Beaucoup Creek, Jackson County, Illinois: (1) just west of Grubbs, and (2) three miles south of Vergennes:

Shells from valley filling near Grubbs

Campeloma decisum, Say
Lioplex subcarinata, Say
Somatogyrus subglobosus, Say
Amnicola limosa, Say
Valvata tricarinata, Say
Pomatiopsis lapidaria, Say
Lymnaea desidiosa, Say
Planorbis bicarinatus, Say
Segmentina armigera, Say
Planorbis deflectus, Say
Sphaerium stamineum, Concord
Corneocylas, sp.

Shells from valley filling 3 miles south of Vergennes

Campeloma decisum, Say
Somatogyrus subglobosus, Say
Amnicola limosa, Say
Ancylus tardus, Say
Valvata tricarinata, Say
Pomatiopsis lapidaria, Say
Lymnea desidiosa, Say
Planorbis bicarinatus, Say
Segmentina armigera, Say
Planorbis deflectus, Say
Sphaerium stamineum, Concord
Corneocyclas, sp.
Pulmonates
Zonitoides minuscula, Binney
Pyramidula anthonyi, Pilsbry
Vertigo gouldi, Morse
Succinea, sp.



Part of Madisonville, Kentucky, topographic sheet, U. S. Geological Survey, showing bed and beach of extinct Green Lake (named from Green River, which now drains the lake bed) and several "island hills." (Note particularly those marked A and B). The thickness of the lake deposit here is about 30 feet, and surface 381 to 395 feet above sea level.

The lime masses may be secretions of blue-green algae, though now they show little organic structure. They are more abundant in the thinner parts of the formation, and this may be due to the fact that lime-secreting algae flourish in very shallow or intermittent waters.

VARIOUS INTERPRETATIONS OF THE LAKE DEPOSITS AND SURFACE FEATURES

Although the deposit under discussion has frequently been noted in the course of general geologic field work, it does not seem to have been considered a distinct formation. It has either been classed with other and better-known surficial formations, or, at most, recognized as something peculiar, and thus seems to have received various interpretations in different parts of the region. Since the results of most of the detailed work in the region have not yet appeared in published form, and since there is only obscure, and uncertain reference to the deposit in the reports published, it is not practicable to give exact and satisfactory references. The deposit, however, seems to have received the following interpretations: it has been regarded as glacial drift; a lowland phase of the loess; an old, normal flood-plain deposit; a backwater deposit from glacial floods on the larger streams; a deposit due to subsidence; or a deposit due to a climatic change. In southwestern Wisconsin, a sandy deposit, no doubt closely related to the clay, has been attributed to the work of streams, whose outlets were blocked by glacial debris and glacial floods. Certain deposits in southwestern Indiana, which have been called stratified loess, differ from the clay under discussion in that (1) they lie at higher altitudes; (2) they are yellowish and soft when dry, whereas the lacustrine clay is greenish and hard when dry; (3) its fossils are almost entirely land shells, whereas those in the lower clay are aquatic.

The clay is not glacial drift, for it contains no stones and but little sand; and much of it lies outside the glacial boundary. Moreover, it is found only in the lowest places, and its upper surface is horizontal, regardless of the underlying surface of hard rock. It is not loess, for it lacks the uniform fineness of grain characteristic of that material, and it fills all depressions up to certain altitudes, not being found at higher positions. Its thickness and other characteristics already described show that it is not a normal flood-plain deposit. The clay could scarcely be a simple backwater deposit due to glacial floods on master streams without the help of a valley train, because the accumulation of such a lake deposit would require a sustained river depth of about 200 feet for thousands of years. A subsidence of the surface might lead to the development of a few bodies of clay, having the shape and arrangement of those under discussion, but warping sufficiently complex to cause the regular arrangement and shape of so many bodies of clay is inconceivable. Nor could the clay deposits have been produced by climatic change, for such deposits slope down stream, and these are horizontal.

These features of the lower parts of valleys tributary to the Mississippi and Ohio,—the broad bottoms in hilly country, the steep valley sides, and the irregularly branching character of the valleys—point toward valley filling. Exposures and well sections also indicate valley filling, for they show that bed-rock is far below the present streams. The limited extent of the clay upstream; the fineness of the material; the fact that the surface is horizontal, and that the clay abuts against thick bodies of coarser material on the large rivers; all indicate that the clay accumulated in lakes produced by valley fillings on the master drainage lines of the region. Therefore, in order to understand the cause and history of the lakes, it is necessary to look into the history of the large rivers.

VALLEY FILLING ON THE MISSISSIPPI AND OHIO RIVERS

General Relations

The Mississippi and Ohio rivers flow in but few places on limestone, sandstone, shale, or other consolidated rock. Throughout most of their courses they flow over a valley filling, the base of which is 50 to 100 feet below the bed of the stream. The deposits consist principally of sand, though there is considerable gravel and silt, the gravel more abundant at the base and the silt predominating at the top of the formation. As shown in figure 8, most of the bottom lands lie below extreme high water, and hence the surface forms a flood plain; but here and there bodies of sand and gravel stand 40 feet above the reach of high water, the upper surface in such places forming a terrace at the altitude of the valley-filling on nearby tributaries. Evidently the river valleys were once filled up to the surface of the filling on the tributaries but now have been almost completely cleared out, less than one per cent of the original surface remaining. Most of the surface of the fill on the Mississippi has been lowered about 40 feet. On the other hand, less than a tenth of the surface of the fill on the tributary streams has been cut away. This contrast is, undoubtedly, due to the greater erosive power of the Mississippi, and to the relative narrowness of its fill, for the valley of the Mississippi is little wider than that of some of its smaller tributaries. The unremoved part of the fill is about 160 feet thick, and extends about 120 below low water, although the range between high- and low-water stages is about 40 feet. This silted-up condition, with certain exceptions, prevails throughout a large region, the fill extending up the Missouri into the Dakotas, and up the Ohio to West Virginia and northern Pennsylvania. A cross-section of the deposits on the Mississippi is shown in figure 8.

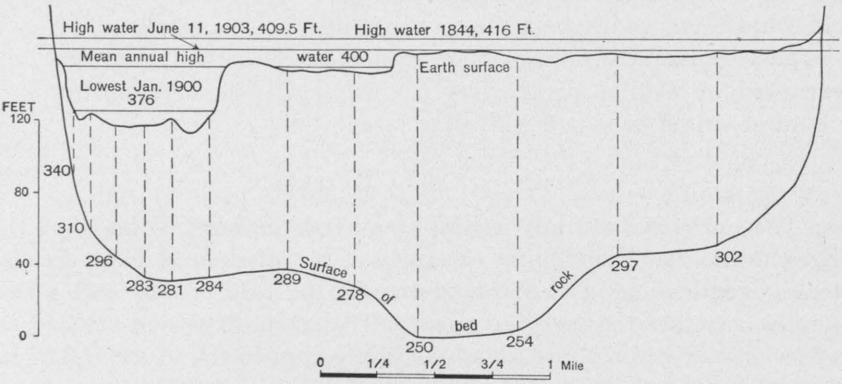


FIG. 8. Cross-section of lower part of Mississippi Valley, 13 miles south of Eads bridge, St. Louis, from borings made by United States Engineers. Vertical lines show borings; horizontal lines show position of water surface at various stages of the river. The upper irregular line represents the top surface; the lower line represents the surface of bed rock underneath the river deposits of sand and gravel. The deepest part of the old valley is about 160 feet below the flood plain, and this holds true at many points along the Mississippi.

Position and Slope of Terraces

The occasional bit of terrace such as at Monks Mound near St. Louis, 40 feet above the flood plain, which corresponds closely in altitude, and in places connects with the fills on the tributaries, indicates that the valley floor was formerly 40 feet above the present one. The old valley floor seems to have had about the same down-stream slope as the present one,—for example, between St. Louis and Cairo the grade was about 7 inches to the mile. These slopes, which are parallel to the present river profile, are high, presumably because the river has dealt with such tremendous loads of glacial material that the gradient has not been reduced to that of streams of like size. The fall of the Nile, from Assuan to Cairo, a distance of over 700 miles, is less than 5 inches to the mile, and the fall of the Amazon is for considerable stretches less than 2 inches to the mile.

Abandoned Parts of Valleys

There is notable absence of buried channels in the vicinity of Keokuk, at Grand Tower, and in other places where the river has forsaken a part of its channel and taken a course to one side. The deep abandoned part of the valley and its buried channel may be easily found in such places; but at Keokuk the old valley has been completely filled with stream and ice deposits and is known only through borings. The new parts of valleys are gorges without buried channels, and the river flows on bed-rock without an intervening bed of sand or gravel. Thus, two distinct kinds of valleys are found here: one along the Mississippi and Ohio being continuous, deep, of medium width, partly filled, and occupied by the rivers throughout most of their courses; the other, interrupted, of medium depth, very narrow, and without filling, forming a kind of cut-off or side-track to the larger valley.

Effect of Delta Extension

The question naturally arises,—may not the partial filling of the Mississippi gorge be due to the extension of the Mississippi delta, because stream lengthening in this way decreases the rate of fall and consequently decreases the carrying power. That delta extension has had an appreciable effect on the work of the Mississippi in the lower end of its course is incontrovertable, but if it has had any effect on its work in Illinois that effect is so obscured by other factors which predominate that it is not recognizable with certainty. Principal among these factors are glaciation, comparatively recent deformation, and the operations of white men. There is some indication that the flood plain south of St. Louis is now being built up, and this may be due wholly or in part to delta extension. Some facts, however, indicate that the Mississippi is at present gradually lowering its channel. Analyses of the water indicate that the river is delivering more mineral matter to the Gulf than that which it carries past Cairo, increased by the additional material received from tributaries between Cairo and the Gulf. In any case, the lakes cannot be ascribed to delta extension alone, for they were developed at rather sharply localized times. Since they existed the main work of the rivers has been down cutting.

Effect of Increase in Stream Volume on Thickness of Alluvium

In this connection, it seems worth while to note that when the volume of a stream is increased, the vertical distance between the bottom of the channel and the flood plain is also increased; and this comes about, not alone by the scouring out of the channel, but also by the building up of the alluvium. Thus, a thick stream deposit may be produced simply by an increase in the volume of water without any change in the size of the load. This, then, is another probable factor in the development of the heavy deposits on the streams flowing away from the ice sheet. The statement is often made that a certain valley was once full, or partly full, of water, but it would probably have taken a flood much greater, and much more sudden than a glacial one, to have produced such a condition, because the discharge of a river increases so rapidly as the water rises that an unthinkable amount of water would be required to cause a 100- or a 200-foot stage. It seems more probable that, with increasing discharge, the channel would enlarge, and perhaps divide, and that a part of the valley bottom would remain at flood-plain level and be dry except during high water.

Explanation of Thickness of Recent Alluvium on the Mississippi.

In time of flood the Mississippi stirs the valley filling to great depths. At St. Louis, it has been inferred that the filling is commonly stirred to its base, for in excavating for bridge piers, bowlders which seemed to have been moved recently were found resting upon scoured bed rock. From this it might be inferred that the enormous body of unconsolidated material along the Mississippi and Ohio is mainly or entirely a normal flood-plain deposit, and that the rivers are, and have been, continuously deepening their valleys; though in order to accomplish this they must stir up a body of sand and gravel 100 to 160 feet in thickness. But the bridge pier excavation at St. Louis was on the side of the valley where bed rock is much higher than out in the middle. The absence of thick sediment wherever the river has forsaken its old course; the presence on the tributaries of a deep filling which certainly is never stirred to its bottom; and the very size of the deposit on the main streams indicates that the Mississippi and Ohio are dealing with something more than a normal flood-plain deposit.

Clearly the logical source of the old filling was glacial and its form was essentially that of a valley train.

FORMATION OF THE LAKES

Causes of the Lakes

The great fillings on the tributaries thus seem to owe their existence to master-stream deposits, which grew more rapidly than the tributaries could build up. The sandy deposit along the main streams is nearly uniform in thickness, and rises up stream, whereas the clay in the tributary valleys has a horizontal upper surface and thins out upstream (see figure 6). At the same time other tributaries not in the region under discussion, were caused to aggrade, and some of them which had greater normal loads, built up as rapidly as the trunk streams. For example, apparently no lake was formed on the Monongahela, that river having built up a body of sand and gravel as rapidly as the Allegheny-

Ohio aggraded, and similarly no lake seems to have been developed on the Sinsinawa in the northwest corner of Illinois.

Age of the Lakes

The age of the lake deposits is evidently late Quaternary. They are younger than the Illinoian till for they nowhere lie beneath that material. Some of it lies on, or cuts through, the till; and some lies on, or cuts through, the loess. From this and the fact that the lake deposit terrace is commonly double, it is inferred that there were two distinct times of lake development, one shortly after Illinoian time and the other in or near Wisconsin time. Some of the later deposit may have been laid down in Recent time, for although it is customary to think of glacial outwash deposits as having developed directly ahead of the ice, it seems to the writer that they may just as reasonably have been formed just after the glacier melted. To be sure, glacial streams generally interlace and built up their beds, and, no doubt, the ice front retreated very slowly. It would seem, however, that a great mantle of gravelly rock-flour would be as likely to cause the overloading of streams, which had gradients adjusted to other conditions, as would the material delivered directly to streams at the ice front. An overloaded condition, in a large stream like the Mississippi, flowing away from the ice, may be caused by an actual increase of material fed, more or less directly, to the streams by the glacier. It may also be caused by a decrease in the velocity, and carrying power of the streams, due either to the attraction of the ice mass or to crustal deformation caused by the weight of the ice. It is also tenable that tributaries, rapidly cutting new valleys in the drift after the melting of the ice, would deliver material to the Mississippi at a rate sufficient to overload it. It is even possible that the debris would be delivered at a more rapid rate than before, when it was carried direct from the glacier to the rivers. These are possibilities which are difficult of evaluation. If aggradation on the Mississippi continued for some time after the Wisconsin ice melted, then the deposit is, in part at least, Recent and not Wisconsin.

Fluctuation of Lakes

The lakes evidently differed from most bodies of quiet water inasmuch as the position of the surface varied greatly every year, because this feature was controlled by the various stages of the rivers. No doubt, many of the lakes were dry a part of every year. Had the range between high and low water been the same then as now, the altitude of the surfaces of the lakes would have fluctuated almost 40 feet. However, the lakes formed a huge reservoir, so that with the same discharge as at present the rivers would not have risen nearly so much in time of flood. Indeed, to raise the surface of the lakes and rivers one foot, it took over 100,000,000,000 cubic feet, or nearly a cubic mile of water. Moreover, every 8-foot rise would have doubled the discharge of the rivers, thus enabling tremendous floods to be accommodated without great increase in depth of water.

Two Periods of Lake Development

There are many interesting details in the history of the lakes, but space will not permit mentioning many of these. Among the most important is the fact that, evidently there were at least two periods of lake development, and that, during the intervening epoch, the first deposit was almost cut through. The deposit in the later lakes is not so high as that of the earlier lakes, and so the two valley fillings are marked by terraces with tops vertically 10 to 20 feet apart.

OTHER EVENTS

There is some indication that, at one time, a part of Mississippi River left its present course 50 miles north of Cairo, and flowed eastward across Illinois to the mouth of the Wabash, but if it did so it did not hold this position long, for it did not do much eroding or depositing. Another fact worth mentioning is that certain valleys in the interior lowland of Illinois are broad and shallow, but have high, steep walls near the Mississippi. During periods of high water the sediment of the Mississippi was carried into these valleys with a current of considerable strength. Thus, at the time the lakes existed, the Mississippi flowed rapidly through the narrow part of the Big Muddy Valleys, toward the broader, inland part, and deposited a great fan-shaped mass of sand, now the site of the town of Murphysboro. The Kaskaskia and other tributaries were similarly, though not so markedly affected.

NAMES FOR THE PROCESSES AND FEATURES

It seems probable that the rather extensive development of deposits, resulting in the topographic features described in this paper, will lead to the introduction of some new, descriptive terms. Perhaps, it will be found convenient to use *contra-gradation* or *dam gradation* to designate stream aggradation caused by an obstruction, or more broadly by decrease in velocity; and perhaps, to invent other terms covering aggradation due to decrease in volume, and increase in load. If the obstruction develops rapidly enough to produce ponded water, as in the case described by the present paper, the deposit taken as a whole will be very fine grained, and the top, though more or less concave, will be nearly horizontal. The bottom of Big Muddy Valley may be used as the type for the resulting topographic feature. In this instance, *Muddy* may be an acceptable name, since it refers to a particular type; to a principal character of the deposit; to the streams which flow over it; as well as to the general character of the country in which it is a feature. On the other hand, when the aggradation keeps pace with the growth of the dam, the material is generally coarser, and the upper surface rises up stream, though more slowly than the original stream channel. For such a process and the resulting topographic feature the development and form of the low terrace along Big Sandy River in eastern Kentucky may be taken as a type, and the surface feature may be called a *Sandy*. Perhaps, it will also be found desirable to designate technically the island-like hills surrounded by the deposit as *Island Hills;* and the hill, which bears the town of Island, Kentucky, may be taken as a type.

SUMMARY HISTORY OF THE LAKE DEPOSITS

In late glacial time, the beds of the rivers were about 100 feet below those of the present time. This great depth may have been produced in a pre-glacial, or possibly an inter-glacial epoch, by a regional uplift; or it may have been caused by the deep scouring of glacial floods. The tributaries entered the flood plains of the Mississippi and Ohio on channel bottoms only about 40 feet lower than those in use today. The tributary flood plains occupied a position near their present channel bottoms, these positions having been controlled by low- and high-water stages of the master streams. At low-water stage no standing water was in the tributaries, but at high-water, the 30- to 50-foot channels were filled by backwater from the rivers, so that, intermittently, long, narrow, winding lakes were formed. When the Mississippi and Ohio began to aggrade, both the low- and high-water marks on them and on their tributaries were raised. At low water, embryo perennial lakes were formed in the channels of the tributaries at their mouths; and at high water the flood plains were covered more deeply than before. The area covered, both at low- and high-water stages, was gradually extended until the low-water stage reached the altitude of the former flood plain. From this time, perennial bodies of quiet water, of considerable size, were on each tributary; and wedge-shaped masses of lake deposit, being nearly 100 feet thick at the lower ends and becoming so thin as to be almost imperceptible up stream, accumulated on the old flood plain.

Nearly all the material deposited in the lakes was fine sediment, such as would be carried in suspension; and the lakes seem to have been filled with this material up to certain concordant positions, probably to the position of a flood plain, or just below the high-water mark of the time.

When the Mississippi and Ohio, after a time, became able to carry not only all of the load delivered to them, but a little more, they began to cut down again. Perhaps, even before this time, the lakes had become intermittent, and at times of high water were drained, for they were almost filled with sediment. The great, flat, lake bottoms became swamps, and channels began to deepen again at the former outlets. At the same time, the swamps began to be drained at the lower ends. The process of swamp draining has continued to the present, and, on medium-sized streams, only 10 to 20 miles of swamp now remain, for the lower 20 to 50 miles have been drained.

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